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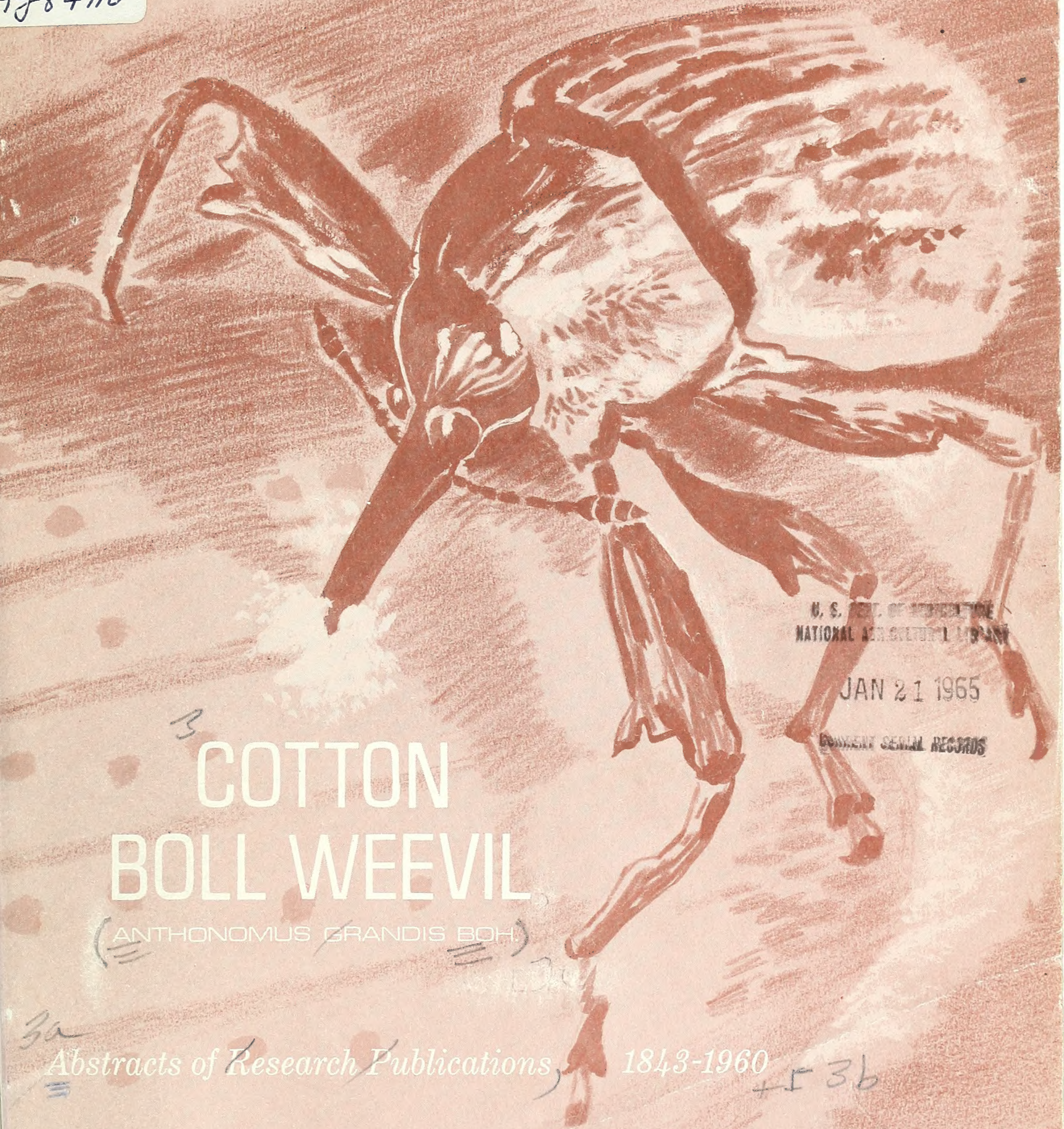

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COTTON BOLL WEEVIL

(ANTHONOMUS GRANDIS BOH.)

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Abstracts of Research Publications, 1843-1960 +5 3b

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UNITED STATES DEPARTMENT OF AGRICULTURE, COOPERATIVE STATE RESEARCH SERVICE

CONTENTS

Some abbreviations used:
B. - bulletin; C. - circular; Col. - college; J. - journal; n.s. - new series; pt. - part; pub. - publication; Q - quarterly; Ser. - series; Serv. - services; U. - university; U. S. D. A. - U.S. Department of Agriculture; v. - volume.

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The cotton boll weevil is the most costly insect in the history of American Agriculture. It is often referred to as the $10 billion insect.

This publication has been assembled to provide researchers with a quick reference to accomplishments in research on the cotton boll weevil and related information published prior to 1961. Researchers are urged to use it only as a reference guide and to refer subsequently to the original publication or report.

The following sources were consulted: State agricultural experiment station publications, U.S. Department of Agriculture publications, professional journals, biological abstracts, Review of Applied Entomology, and the U. S. D. A. Bibliography of Agriculture.

Abstracts in each major section are arranged chronologically by year of appearance in print. Authors are arranged alphabetically within each year.

An author index is included.

In the preparation of this publication, the author gratefully acknowledges the assistance of Drs. S. E. Jones, C. F. Rainwater, C. R. Parencia, and T. B. Davich, Entomology Research Division, Agricultural Research Service, U.S. Department of Agriculture; Dr. F. S. Arant, Department of Entomology, Alabama Agricultural Experiment Station; Dr. J. C. Gaines, Department of Entomology, Texas Agricultural Experiment Station; and Dr. L. D. Newsom, Department of Entomology, Louisiana Agricultural Experiment Station.

COTTON BOLL WEEVIL

(Anthonomus grandis Boh.)

Abstracts of Research Publications, 1843 - 1960

Compiled by Henry A. Dunn
Cooperative State Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

CONTROL - CHEMICAL

1898 - Sanderson, E. D. The Mexican cotton boll weevil. Farm & Ranch 17(47):3-4. Nov. 19.
Recommends spraying volunteer cotton with Paris green and plowing out and burning plants in November.

1900 - Mally, F. W. Protecting the cotton crop from insect pests. Tex. Farm Cong. Proc., 3:183-185.
Use of poison against the boll weevil, also migration and trapping of weevils.

1901 - Mally, F. W. Arsenate of lead against cotton insects. Tex. Farm Cong. Proc., 4:103.
Arsenate of lead as a boll weevil spray.

1904 - Anonymous. The cotton boll weevil. Trop. Agr. 24(4):228.
Mention is made of cultural methods in their relation to the prevention of injury by the cotton boll weevil. When the cotton is sprayed with a solution of sulfate of copper at the rate of 2-1/2 lbs. per 40 gal. of water, a sufficient quantity of this substance is absorbed to kill the cotton boll weevil when it attempts to feed. This method of treatment was estimated to cost about 15¢ to 20¢ per acre.

1904 - Hunter, W. D. The use of Paris green in controlling the boll weevil. U. S. D. A. Farmers' B. 211, 23 p.
The results of extensive laboratory and field tests, as well as results of field tests made by cotton planters, show that the use of Paris green as a means of controlling the boll weevil was futile.

1904 - Hunter, W. D. The use of Paris green in fighting the boll weevil. Tex. Stockman & Farmer 23(29):2, 14-15. June 8.
The results of experiments to determine the effect of applying Paris green to volunteer plants as a means of destroying boll weevils.

1904 - Marston, B. W. Experience in poisoning the boll weevil. La. Boll Weevil Conv. held at Shreveport, La. 2d Ann. Meet. Proc. La. Crop Pest Comn. C. 2:65-83, 88-96.
A paper relating to the use of Paris green, by the writer, against the weevil, also letters from planters regarding its use. Pages 88-96 discuss Mr. Marston's paper.

1907 - Marston, B. W., L. S. Frierson, and W. Newell. Report of the executive committee upon the Paris green experiments conducted against the boll weevil during 1905. La. Crop Pest Comn. C. 8:31.

A test was made of Paris green as a means of controlling the cotton boll weevil. This remedy was applied to cotton kept under large wire-screen cages and under field conditions.

The season was unfavorable to the work on account of the late development of cotton and other difficulties met with in applying Paris green at the most effective period. When Paris green was applied at the rate of 10-3/4 lbs. per acre, in each of 4 applications, nearly all of the boll weevils were destroyed. The insects were greatly reduced in number by the use of 2-7/8 lbs. of Paris green per acre also in each of 4 applications. The use of the large quantity of Paris green resulted in considerable injury to the cotton and a diminished yield.

The general conclusion reached from this series of experiments is that if Paris green is applied to cotton that is blooming and squaring, the number of boll weevils will be reduced but the injury to the cotton is quite serious. It is suggested that during average seasons better results might be obtained if Paris green were applied earlier.

1908 - Newell, W., and T. C. Barber. Preliminary report upon experiments with powdered arsenate of lead as a boll weevil poison. La. Crop Pest Comn. C. 23:9-40, 3 fig.

A brief review of the use of Paris green in combating the boll weevil. Experiments with a powdered arsenate of lead showed it to be twice as effective as Paris green; when applied to cotton just before the first squares formed, 70% of the boll weevils present were killed. Conclusions as to the probable profit following such application should be drawn with caution, since all the boll weevils are not out of hibernation when the squares first appear. For the destruction of the cotton caterpillar or leafworm in summer, powdered arsenate of lead was preferred to Paris green since it was equally effective, noninjurious to cotton plants, and cheaper. Powdered arsenate of lead was also considered a better application for the boll worm than Paris green.

1908 - Newell, W., and T. C. Paulsen. The possibility of reducing boll weevil damage by autumn spraying of cotton fields to destroy the foliage and squares. J. Econ. Ent. 1:113-117.

Discussion of experiments with various chemical sprays used in an effort to destroy cotton plants in fall without injuring lint. A 3% solution of iron sulfate accomplished good results.

1909 - Newell, W., and G. D. Smith. Experiments with powdered arsenate of lead as a practical boll weevil poison. La. Crop Pest Comn. C. 33:252-333, 1 pl., 3 fig.

On May 28, powdered arsenate of lead was applied to approximately 1/2 of a 9-acre field by means of a champion dust sprayer, 1 lb. per acre. When the cotton was picked, 5,068 lbs. were taken from the poisoned plots of 4.38 acres; 4,638 lbs., from the nonpoisoned plot of 4.712 acres.

In experiments with a liquid spray of lead arsenate, gains were too small to justify the expense. To determine whether a high percentage of weevils could be killed when squares and bolls were present on the plants, cage experiments with powdered arsenate were made. The percentage of weevils killed by the arsenate on fruiting cotton was considerably smaller than that on small cotton in the budding stage, but these experiments indicate that applications of powdered arsenate should be continued after the first squares appear on the plants in spring.

It is concluded that the best results are obtained with 5 applications, made from 5 to 7 days apart, starting when the first squares form. Following the first and second applications of from 2 to 2-1/2 lbs. per acre, the amount of arsenate should be increased until at the fifth, from 4 to 7 lbs. per acre should be used. Getting the poison into every terminal bud, into every blossom, and into the involucre of every square is essential.

An experiment conducted at midsummer in Baton Rouge is thought to demonstrate the futility of trying to attack the boll weevils with the arsenate of lead late in the summer. Experiments made by private parties are also considered.

1916 - Howard, L. O. Report of the entomologist for the year ended June 30, 1916. U. S. D. A. Bur. Ent. Rpt. 24 p. Aug. 24. Wash.

"Investigations of southern field-crop insects showed that the boll weevil was the principal pest to be considered in relation to cotton culture. A new type of poison dust gun and also a form of lead arsenate containing a higher percentage of arsenic were tested with excellent results in increased production."

1918 - Coad, B. R. Recent experimental work on poisoning cotton boll weevils. U. S. D. A. B. 731, 15 p., 10 fig. July 19. Wash.

Attempts to control the Mexican cotton boll weevil by the use of poisons have been made almost from the time of its first appearance; the results, however, have always been discouraging. This is attributed to the fact that the weevil derives its food from deep punctures, thus ingesting very little of the poisoned external plant tissues. Studies on the boll weevil under cage conditions during 1913 and 1914 showed that water was essential to its continued existence, and from this fact was derived the idea of poisoning the water which the weevils drink.

The first tests of this nature were begun in 1915. The results showed that every poisoned plot yielded more than the untreated controls, the most pronounced feature being the greater increase in yield with the larger number of poisonings. Thus, with 4 applications, a gain of about 15% was secured; with 5, this gain was increased to about 35%; while 6 applications increased it to 70%. As all applications were begun at the same time and the extra ones simply meant the continuation of the treatment until later in the season, the importance of applications late in the season seemed obvious.

Similar experiments in 1916 were carried out, the results being quite as definite as those of 1915, demonstrating the importance of applications late in the season.

About the middle of August 1917, experiments on a large scale were possible where late planting and adverse weather conditions had combined to produce an exceptionally heavy weevil infestation. One application of poison was given, and 10 days later the number of punctured squares had been reduced from 86% to 36%, thus showing poisoning to be a very profitable operation.

In the course of these experiments many different poisons were used, and nearly all arsenicals were effective to a certain degree. The best results, however, could be obtained with either di-hydrogen lead arsenate, containing not less than 32% of arsenic pentoxide, or with a calcium arsenate containing at least 42% of arsenic pentoxide. Both of these were effective controls, if properly used. The physical condition of the poison was fully as important as its chemical composition, the fine powder being more rapidly taken up by the dew and held in suspension for the weevils. The most effective forms were powders of a density ranging from 80 to 160 cubic inches per pound.

The optimum season of application was at the time when the weevils were doing their maximum injury to the crop and when the cotton manifestly slackens in blooming. Once a week constituted an effective interval between applications. Much more effective poisoning with dry dust could be conducted while the dew was on the plants. It was found advisable to poison as much as possible during the evening, night, and early in the morning--during the day only in case of emergency.

The experimental average of 5 lbs. per acre was obviously excessive; with improved machinery, effective poisoning was accomplished with a much smaller amount. The number of applications varied with the size of the plot to be dusted. A single application over a large area was as effective as three on a small one because of the constant migration of further weevils into the latter.

The cost of treatment varied widely. In experimental work it averaged about 80¢ an acre for each application. With improved machinery and the use of carriers this can be much reduced. A further economy may be effected if several applications are given that part of a plantation near the hibernation quarters of the pest before the weevils have become sufficiently abundant to start movement. The remainder may then need only a single application.

1918 - Howard, L. O. Report of the entomologist. U. S. D. A. Bur. Ent. Rpt. 24 p. Sept. 19. Wash.

"Work against southern field-crop insects carried out under Dr. W. D. Hunter have resulted in the discovery that the cotton boll weevil . . . can be controlled by dusting with lead arsenate or calcium arsenate."

1919 - Ballou, H. A. The poisoning of the boll weevil. Agr. News, 18(443):122-123. Apr. 19. Barbados.

Success of experiments in the United States to control the Mexican cotton boll weevil on a large scale by means of poisons; methods of application and machinery used.

The poison used was a calcium arsenate containing not less than 40% arsenic pentoxide and not more than 0.75% of water-soluble arsenic and of a density of not less than 80 cubic inches per lb. The poison was applied as a dust, 6 lbs. being required per acre for each application. The fields were sprayed from 2 to 4 times during the season; in the event of heavy rain within 24 hours, the dusting was repeated. The best time for application was when the leaves were damp and the air calm. The power duster was able to cover at least 6 acres an hour; whereas the capacity of each hand dust gun is about 5 acres per day.

1919 - Hinds, W. E. Cotton worm control. Ala. Agr. Expt. Sta. C. 42:63-67, 2 pl. Aug. Auburn.

"The boll weevil may be controlled with calcium arsenate applied by means of a dust gun so as to drive the poison well through the plants. This treatment should be applied weekly and maintained as long as the cotton continues to grow and set bolls."

1919 - Hinds, W. E. Report of entomologist. Ala. Agr. Expt. Sta. Rpt. 31:27-29. Jan. Auburn.

"Experiments with lead arsenate and other poisons in dust forms against the boll weevil . . . on cotton are being continued."

1919 - Hinds, W. E. Annual report of the director of the experiment station on work done under the Local Experiment Law in 1919. Ala. Agr. Expt. Sta. C. 43. Auburn.

A report of cotton dusting with calcium arsenate on three farms in Alabama. One farm showed a profit of $20 per acre from dusting; one, $22 per acre; and the third showed doubtful profit. Although farmers are interested in dusting, very few are willing to take steps to provide machinery and poison necessary until its value is completely proven.

1919 - Hinds, W. E., and F. L. Thomas. Poisoning the boll weevil. Ala. Agr. Expt. Sta. B. 212:53-84, 1 pl., 16 tab. Nov. Auburn.

Dusting experiments with calcium arsenate against the boll weevil carried out in Alabama from 1918 to 1920. In 1918 the rate of application varied from 1 to 5 lbs. per acre at intervals of about 14 days, but the slight increase in yield did not warrant the expense of dusting. This failure was partly due to weather conditions, the heat and drought controlling most of the weevils. Also, the intervals between applications were too great and the work was not continued long enough for the results to become cumulative under existing conditions. Experiments showed that the weevils will live without water for a short period, at least, and that dew is not indispensable in poisoning them. Moisture on the plants after the poison had been applied did not increase the mortality. In 1919, experiments on the cost of dusting with calcium arsenate showed that it was advisable to keep the acreage of cotton moderate and to make that area as fertile as possible so as to increase its productiveness. Under these conditions, should a heavy weevil infestation be indicated, the pest may be reduced to below 30% by dusting every 5th day until after a full crop of bolls is beyond weevil damage.

In all counties where the weevil caused an average decrease in yield of more than 20% during 5 consecutive years, dusting is likely to be needed regularly each year.

Owing to the influence of meteorological conditions in controlling the weevil, dusting was not advised if the weather continued sufficiently hot and dry for more than a month, especially during the first part of the fruiting season. Dusting was recommended, otherwise, at the usual 4- or 5-day interval, even in spite of threatening weather.

Crops dusted with calcium arsenate more than offset the cost of dusting. Estimated cost was $1.18 per acre. Returns were from $18 to $36 per acre. A gas-driven dusting machine was developed.

1919 - Howard, L. O. Report of the entomologist. U. S. D. A. Bur. Ent. Rpt. 27 p. Aug. 14. Wash.

"The use of powdered lead arsenate or calcium arsenate against the cotton boll weevil . . . which was advocated in last year's report, is being greatly extended with promising results, but care is required in its application, and instructions are being distributed for this purpose."

1920 - Anonymous. Service and regulatory announcements. U. S. D. A. Insect and Fung. Bd. Announcement 27:609-640. Feb. 20. Wash.

Includes a notice to manufacturers relative to the labeling of calcium arsenate for use against cotton boll weevil and notices of judgments given under the Insecticide Act of 1910.

1920 - Coad, B. R., and T. P. Cassidy. Cotton boll weevil control by the use of poison. U. S. D. A. B. 875, 31 p. July. Wash.

The system of poisoning described does not aim at the extermination of the boll weevil, but only at a sufficient reduction of infestation to permit the maturing of a full crop of cotton. This depends on the habit of the cotton plant to produce much more fruit than it is able to mature. About 60% of the squares fail to reach maturity as bolls and are shed sometime during development. This shedding is comparatively slight early in the season. It increases rapidly as the plants develop, until it reaches the point when all the new fruit that appears is shed. Up to a certain point the fruit shedding due to boll weevil attack merely takes the place of the normal shedding which would occur even if the weevils were absent.

Generally speaking, weevils were permitted to multiply unmolested until they became sufficiently abundant to puncture more squares than would be shed normally. Poisoning was then started, and every effort was directed toward holding the infestation below this point of danger until the plants had sufficient time to develop, beyond weevil injury, as many bolls as they were able to mature. Remarkably large increases of yield frequently resulted from the comparatively slight degree of control for a short time during this critical period. A satisfactory effect can be secured only by starting applications at the right time and repeating them at correct intervals.

The time of starting depends on the percentage of squares in the field that are weevil punctured. As a general rule, operations should start when from 15% to 20% of the squares are punctured, and should be repeated often enough to prevent the infestation rising above 25% until the crop is set and the bolls safe from the weevil attack. In certain cases on large plantations it may be possible to confine the weevils to the fields in which they first appear, near their hibernation quarters, as they will not migrate to the adjoining cotton if their numbers are kept down.

A 4- or 5-day interval between applications is best. The effect of the poison does not last long, and this interval results in the successful control of the progeny of the first weevil attack if three applications are made under average conditions; more applications are necessary if a longer interval is allowed. If anything happens to interfere with the schedule for a day or so, it can still be continued; whereas if a longer interval were scheduled, all control would be lost.

The poison is calcium arsenate, used as a dust, with the following specifications: Not less than 40% arsenic pentoxide; not more than 0.75% water-soluble arsenic pentoxide; density not less than 80 nor more than 100 cubic inches per

pound. Without the first specification, the poison will not be sufficiently insecticidal; without the second, it may scorch the plants; without the third, it will not produce a suitable dust cloud.

The danger of the poison to man and animals is slight if proper precautions are taken, but the risk of inhaling the poison or of absorption through the skin, as well as that of swallowing it, must be borne in mind. The poison is best applied at night when the humidity is high and the air calm. Rain washes it off much more readily if it has been applied in very dry weather.

Dusting machinery is of three kinds: hand guns, cart dusters, and power dusters. Hand guns are suitable for only very small areas, or to supplement the cart duster. The latter is hardly justified for less than 75 acres. Power dusters are not very satisfactory.

The expense of poisoning varies in different circumstances. Generally it is hardly justified unless the land is fertile enough for the plants to take full advantage of the treatment, and unless the land would produce at least 1/2 a bale of cotton an acre if there were no weevils.

Calcium arsenate can also be used in the control of cotton leafworm, fall army worm, etc. But if the weevil equipment is used solely for leafworm control, the expense may be considerably reduced by mixing lime in equal parts with the calcium arsenate and applying the mixture at the rate of 4 or 5 lbs. an acre.

1920 - Ferris, E. B. Cotton growing in south Mississippi. Miss. Agr. Expt. Sta. B. 196, 8 p. Dec.

Until the season of 1920, the Mississippi Station had made no attempt to control the cotton boll weevil with poisons. In that year the damage was so great that some growers ploughed up their cotton and planted the lands in other crops. On the station farm, in spite of several hand-pickings, many of the cotton stalks had every square punctured. Hand dusting was then begun with calcium arsenate, 3 applications being given at intervals of about 6 days. After this treatment, the percentage of infestation was so low that poisoning was stopped for a time and begun again late in July. It is uncertain whether the good results were due to poisoning or to the frequent rains that began about the same time.

1920 - Howard, L. O. Report (1919-1920) of the entomologist. U. S. D. A. Bur. Ent. Rpt. 36 p. Sept. 7. Wash.

"With regard to southern crop pests, the use of calcium arsenate against the cotton boll weevil . . . has been greatly extended. Suitable dusting machinery by wheel-traction power has been devised, motor power dusters proving unsuitable."

1920 - Newell, Wilmon, and Eli K. Bynum. Notes on poisoning the boll weevil. J. Econ. Ent. 13(1):123-136.

1. The mortality among boll weevils on cotton plants treated with lead and calcium arsenates, and kept protected from all rain and dew, was appreciably higher than the mortality on plants similarly treated but exposed to dew and normal precipitation. Because the presence of dew or rain water on the cotton plants did not increase the effectiveness of either lead or calcium arsenate as a boll weevil poison, it was evident that mortality from the use of either of these poisons was brought about by ingestion of the poison with the weevil's food and not by drinking the so-called "poisoned dew."

2. Dew collected from cotton plants treated with lead arsenate at the rate of approximately 8 lbs. per acre contained 6.7 p.p.m. of arsenic. Dew from plants treated with calcium arsenate at the same rate contained from 10.0 to 43.5 p.p.m. of arsenic. The dew was collected only from cotton leaves that showed a distinct, thorough white coating of the arsenates.

3. Boll weevils, deprived of all food and having dew from treated plants as the only source of moisture, suffered a greater mortality than boll weevils confined on clear water. This showed that the dew contained sufficient arsenic to produce death when the weevils were compelled to take the dew, and no other food

or water, over a period of several days. However, such a condition does not occur in cotton fields.

4. When boll weevils had access to food in the form of nonpoisoned cotton squares and, at the same time, to dew from treated plants, no mortality resulted. This showed that the weevil can be poisoned under normal conditions only by poisoned food.

1920 - Warren, D. C. Dusting cotton for the control of boll weevil. Ga. Sta. Bd. Ent. B. 56, 15 p., 2 fig. Feb. Atlanta.

While a considerable amount of experimental work has been done in various parts of the United States in dusting cotton for the cotton boll weevil, it was essential that special tests be made in Georgia. Particulars are given of the experiments and the results show that the method was successful in practically every case. Directions are given for applying poison; the various materials that may be used, of which calcium arsenate gave the best results; the dosage and number of applications; and suitable machinery.

1921 - Brown, H. B., and J. F. O'Kelley. Cotton experiments. Miss. Agr. Expt. Sta. B. 205, 15 p., 2 fig. Dec.

Boll weevils appeared in the college cotton fields in Mississippi as early as June 13, 1921. On June 24 ordinary calcium arsenate dust spray was applied, but there was hardly sufficient dew to make it successful. This poison was afterwards applied in a water solution. A further mixture was made of 1 lb. calcium arsenate, 1 U.S. gal. blackstrap molasses, and 1 U.S. gal. water. The latter was more expensive and troublesome to handle than the former, but seemed to adhere better and was sometimes visible when showers had washed off the other poisons.

1921 - Coad, B. R. Killing boll weevils with poison dust. U. S. D. A. Ybk 1920:241-252, 2 fig.

These experiments proved that the cotton boll weevil can be controlled by calcium arsenate dust. Experiments with this poison were extensive in 1920, and the reasons for their success and failure are discussed.

1921 - Coad, B. R., and T. P. Cassidy. Some rules for poisoning the cotton boll weevil. U. S. D. A. C. 162, 4 p. Jan. Wash.

Briefly states the information needed by farmers when considering the advisability of poisoning the cotton boll weevil and the best means of doing it.

1921 - De La Barreda, L. El arseniato do calcio contra el Picuda del Algodonero. (calcium arsenate against Anthonomus grandis Boh). Rev. Agr. 11:770-774, 9 fig. Mar. San Jacinto, D. F.

The information given in this article is on the use of calcium arsenate against the cotton boll weevil.

1921 - Howard, L. O. Report of the Chief of the Bureau of Entomology and Plant Quarantine, 1920-21. U. S. D. A., 33 p. Aug. 1. Wash.

"Among Southern crop pests the cotton boll weevil . . . was treated by dusting with dry powdered calcium arsenate on a large scale, 75,000 acres of cotton being dealt with. A brief summary of rules for poisoning has been issued, and is widely used by farmers."

1921 - Parrott, P. J. The seasons experience with insects and insecticides. N.Y. State Hort. Soc. Proc. 66:17-37. Rochester.

"Hitherto, calcium arsenate has been chiefly used against the cotton boll weevil . . . for which purpose about 10 million pounds were allotted to the Southern States during 1920."

1921 - Tanquary, M. C., and H. J. Reinhard. Dusting cotton for the control of the boll weevil. Tex. Agr. Expt. Sta. C. 29, 9 p., 1 fig. Apr. Col. Sta.

The dusting method for the control of the cotton boll weevil, as developed by Coad, proved successful under Texas conditions. A list of precautions is given as a guide for those adopting this method.

1921 - Warren, D. C. Cotton dusting experiments of 1920. Ga. State Bd. Ent. B. 59, 16 p. Feb. Atlanta.

During 1920, experiments were undertaken to determine more accurately the value of using calcium arsenate to kill the cotton boll weevil in Georgia. The results showed that this poison, properly applied, is a successful remedy. In heavy infestations the dust should be applied once or twice, just before the squares are large enough to be punctured. While they are being attacked, 2 or 3 dustings should be given at intervals of 3 or 4 days, until the weevils are under control. The applications should then be discontinued until infestation begins again. From 5 to 7 lbs. of dust should be used per acre each time. Considerably better results are obtained by dusting while the dew is on the plants. The calcium arsenate used should be of standard composition.

It was impossible in 1920 to estimate accurately the profits gained by dusting; it is now considered that a gain of 100 lbs. of seed cotton will pay the cost of poisoning. Average gains were considerably above this. A limited number of tests were made to determine whether dusting would be profitable while the plants are very small and the weevils that have survived the winter are feeding on the buds.

1922 - O'Kane, W. C. One year of the Crop Protection Institute. J. Econ. Ent. 15(3):209-213.

The first year of work is briefly reviewed. A conference was held in New York on the control of the cotton boll weevil, and a concise statement of rules relating to dusting against this past was prepared.

A cooperative dusting project in several States was successfully carried out under the direction of the Institute, which proved the organization to be an available means of bringing about profitable and desirable cooperation among investigations.

1922 - Smith, G. D. Preliminary report upon an improved method of controlling the boll weevil. Fla. State Plant Bd. Q. B. 7(1):1-64, 13 fig. Oct. Gainesville.

A study of boll weevil conditions in Florida suggested that the first generation of weevils could be destroyed by stripping from the cotton plants the first squares of the season, and with them the eggs deposited by the weevils after hibernation. Care must be taken that all weevils are out of their winter quarters before this is done. In normal seasons, the squares should be removed between June 5 and 8 and followed by a thorough application of calcium arsenate or lead arsenate at the rate of 5-7 lbs. per acre, using a suitable dusting machine. The weevils, deprived of squares in which to hide and feed, will attack the terminal buds for food, and these buds can easily be filled with poison by means of a dust gun. This method destroyed practically every weevil that had escaped capture in the stripping operation. [A table recording emergences of the weevils at various places shows that 99% are out of hibernation and in the cotton fields by June 5.] In order to get the plants into the right fruiting stage for treatment, nonfertilized cotton should be planted about the last week in March. If much fertilizer is used, planting should be one week later. If the season is unusually late, the treatment should be delayed for a few days, until enough squares have appeared on the plants to act as traps for the adult weevils.

The effect of stripping the squares on the yield of cotton is discussed, and the life history of the weevils in Florida, with a view to satisfactory application of the remedies, is dealt with. The second generation of weevils matures about August 5, at the earliest, and by this time the Florida crop of short staple is sufficiently matured to escape practically all damage by the weevils. Many field tests with these methods are recorded in detail, and the best method of removing the squares and of applying the poisons are explained.

1922 - Warren, D. C. Results of cotton dusting experiments for 1921, together with summary of the dusting results of past three years. Ga. State Bd. Ent. B. 62, 9 p. Mar. Atlanta.

The dusting experiments against the cotton boll weevil, carried out for the past few years in Georgia, have shown that calcium arsenate dust gives the best results. Where infestation is at all heavy, 2 applications, using 5 lbs. per acre, should be made, with an interval of 3 or 4 days, just before the cotton squares begin to form sufficiently for oviposition. Afterwards, the field should be examined closely, and where punctured squares appear, they should be picked off and the plants dusted. If the infestation is spreading generally, dust should be applied every 5 or 6 days, or 3 or 4 times at 4-day intervals. Dusting on damp, foggy days gives better results than in dry weather. Dusting should be continued until the bolls are matured at the top of the plant. Night or early in the morning is the best time to dust.

1922 - Warren, D. C. Relation of moisture to ingestion of poison by the cotton boll weevil. J. Econ. Ent. 15(5):345-349.

In view of the difference of opinion as to whether moisture is essential for the cotton boll weevil to ingest poison, further experiments are here described. In 1920, 72 hours after the poison (calcium arsenate) had been applied, there was a mortality of 45% amongst weevils feeding when there was no dew, although they remained on the poisoned plant a much shorter period than weevils feeding when dew was present and there was a mortality of 35%. In 1921 the mortality of the former was 85% for a period of 96 hours; 71% for the latter. From these results and those of other authors, it is clear that weevils are poisoned by ingestion of poison with their food, rather than by drinking the poisoned dew. This conclusion has nothing to do with the time of day when the poison is applied, as it is established that better results are obtained from applying poison while the plant is wet with dew.

1923 - Ames, C. T. A progress report of boll weevil poisoning work at the Holly Springs Branch Experiment Station. Miss. Agr. Expt. Sta. C. 51, 11 p. Dec.

As the result of experiments against the cotton boll weevil in Mississippi, it was recommended that poisoning should begin just as the squares begin to form. Where labor is plentiful, a mixture consisting of 1 lb. calcium arsenate to 1 U.S. gal. treacle and 1 U.S. gal. water should be applied with a mop to the top bud. Where labor is scarce, a dusting machine should apply calcium arsenate dust in the bud. Earlier than this the poison would be useless. About 10 days later, a second application of dust should be made by a machine. On hill lands these 2 applications may be sufficient, but in valleys or lands where cotton grows rank, if infestation reaches 10%, a third application of dust should be made.

1923 - Barre, H. W. Boll weevil control. S.C. Agr. Expt. Sta. Rpt. 36:18-29, 4 fig. Dec.

Before the squares formed, applications of either a sweetened poison made of calcium arsenate, treacle and water, or calcium arsenate dust, killed a large percentage of weevils in the field; in some cases 80% to 98% of the weevils were found dead 96 hours after the applications were made. The dry dust was more effective when applied while dew was on the plants. In no case, however, were weevils completely eliminated from fields by 3 or 4 applications of either liquid or dry poison in June.

The indications are that when initial infestation is reduced to a minimum by means of these early applications, the time for mid-season and later applications of dust will be delayed. Little increase in yield of cotton was produced by the early applications alone.

After the plants are large enough for blooming freely, the only means of reducing infestation is by the use of a dust cloud of calcium arsenate applied with a machine that thoroughly atomizes the dry dust and drives it down through the cotton plant. Liquid poison, applied later in the season, seems to prevent rapid increase but does not hold the weevil in check after the rains start in mid-July.

Detailed results on certain farms are recorded, showing that late applications (August and early in September) were very successful. Of other poisons commonly used for various insects, nicotine gave the most promising results. A 2% dust gave as good results as one with higher nicotine content, while no injury was done to the plants. These experiments, however, are not yet completed.

Suitable machinery for dusting is discussed. Hibernation records showed that about 5% of weevils hibernating in woodlands survived the winter of 1922-23.

1923 - Coad, B. R., and T. P. Cassidy. Dusting for the cotton boll weevil. U. S. D. A. C. 274, 3 p. May. Wash.

This circular was prepared to give, in a brief and concise form, the information needed by cotton growers to help them decide whether it would pay them to poison for Anthonomus grandis and what methods they should follow.

1923 - McDonald, R. E. Report of the entomologist. Tex. Comn. Agr. Rpt. 16:33-38. Nov. 1. Austin.

"In view of the large number of machines that have recently been put on the market for catching boll weevils . . . tests were organized for a comparison of their efficiency. In many instances, however, the infestation was so slight that no determination could be made. The results of 20 different methods are briefly summarized.

Experiments with calcium arsenate dusting, the Florida method, and poisoned molasses were carried out, but, as the infestation on all plots was always lower than 10%, the results of these tests are not absolutely reliable."

1923 - McGehee, T. F. Preliminary report on early poisoning on boll weevil control. Miss. State Plant. Bd. Q. B. 3(3):1-15, 3 fig. Oct.

The method of poisoning, as a remedy for the cotton boll weevil, recommended in this preliminary report is the application of calcium arsenate, either in dust form or with molasses as a liquid, to the terminal buds of young plants just before any squares form. Another application is made 10 days later, preferably of the dust, instead of waiting until 10% to 15% of the squares are punctured. This method has been tested for only one year, but is considered very promising. As both liquid and dust gave practically uniform results, where labor is cheap and the acreage small, the liquid may be preferred, but in most cases the dust will be cheaper. When this method is used, the fields should be closely watched during July and August in readiness for a dust application of calcium arsenate if 10% of the squares become infested. This is particularly likely to occur if the fields are in the vicinity of untreated cotton, and points to the necessity for cooperative action. The advice of the nearest experiment station should be followed in regard to crop rotation, soil preparation, fertilization, varieties, planting, spacing, and cultivation.

1923 - O'Kelly, F., and R. Cowart. Cotton experiments, 1923, varieties, fertilizers, and weevil control. Miss. Agr. Expt. Sta. B. 219, 11 p. Dec.

The results of poisoning the boll weevil by the Coad Method are described, the cost of the poison and its application are worked out. The average gain of cotton per acre is shown to be 635 lbs. The outstanding drawback to this method is the lack of satisfactory machinery for applying the poison.

1924 - Ames, C. T. Boll weevil poisoning work. Miss. Agr. Expt. Sta. C. 54, 12 p. Dec.

Presents rather detailed results of experiments with sweetened calcium arsenate poisons.

1924 - Hinds, W. E., and W. G. Bradley. La. Agr. Expt. Sta. Ann. Rpt. Dept. Ent., p. 18-30. Baton Rouge.

The cotton boll weevil was largely controlled by natural factors. In comparative tests with calcium arsenate and lead arsenate, the former, on the whole, gave the better results. In all tests there was an average of 4% greater mortality when the dusts were applied to plants moist with dew.

1924 Howard, L. O. Report (1923-24) of the Entomologist. U. S. D. A. Bur. Ent. Rpt. 30 p. Wash.

"The use of calcium arsenate against the cotton boll weevil . . . is now becoming so general as to make the results more or less a matter of local and seasonal conditions. Particular attention was given to a study of the increase of infestation by aphids that sometimes accompanies the use of the poison. This can usually be avoided by proper modification of the poisoning schedule without interfering with the successful control of the weevil. The use of aeroplanes for dusting is being developed, and at least 5 distinct types of dusting equipment have been devised to meet the requirements of the different flying characteristics of the aeroplanes employed."

1924 - Isely, D., and W. J. Baerg. The boll weevil problem in Arkansas. Ark. Agr. Expt. Sta. B. 190, 22 p., 8 fig. Jan. Fayetteville.

A general account is given of the cotton boll weevil in Arkansas. The early production of cotton and the destruction of the weevils in hibernation are recommended. Early infestations may be checked by applications of calcium arsenate dust, 5 to 7 lbs. per acre, which should be given only where weevils actually occur. The treatment should begin when the weevils have punctured 10% to 15% of the squares, and be continued for 3 or 4 applications at intervals of 4 or 5 days.

1924 - Leiby, R. W., and J. A. Harris. Habits and control of the cotton boll weevil in North Carolina (progress report of its life history and control made during 1923). N.C. Dept. Agr., 19 p., 7 fig. Mar. Raleigh.

Tests of remedies for the cotton boll weevil in North Carolina during 1923 indicate the advisability of giving one application of homemade poison, consisting of 1 lb. calcium arsenate and 1 U.S. gal. each of molasses and water, just when the squares begin to form, the poison being applied with a mop to the buds. It is considered that when 4 to 7 applications are mopped on the plants during the season (especially the fruiting time) the cost is as great as, or greater than, the value of the cotton gained by the treatment.

The Florida Method is not recommended for general adoption. It is recommended that the 1 mop poisoning be followed up by 4 to 7 applications of calcium arsenate dust, beginning when 10% of the squares are punctured, and continuing at intervals of 4 or 5 nights at the rate of 5 to 7 lbs. of poison per acre. The dust should be driven into the squares. Dead weevils will frequently be found there afterwards.

1924 - Marcovitch, S. Sodium fluosilicate. Indus. Engin. Chem. 16:1249, Easton, N.Y.

Pure sodium silicofluoride was found to be an efficient insecticide against the cotton boll weevil. In cage tests all weevils were killed in from 5 to 24 hours. The weevils died even after mere contact with the powder. The advantages of this substance over arsenical compounds are that it is cheaper, it acts as a contact poison, kills more rapidly, and is less poisonous to man. The disadvantage of the commercial product is its density.

1924 - Marcovitch, S. New insecticides for the Mexican bean beetles and other insects. Tenn. Agr. Expt. Sta. B. 131, 19 p., 7 fig. Oct. Knoxville.

"Sodium fluosilicate 1-9 was equally effective against Leptinotarsa decemlineata (potato beetle), Epitrix cucumeris (potato flea-beetle), etc., but when undiluted with lime, it caused some injury to plants. In all tests conducted with Anthonomus grandis (cotton boll weevil), the weevils were killed in from 5 to 24 hours. Cotton is a comparatively resistant plant, and is not injured, even when the substance is used undiluted."

1924 - Nickels, C. B. Results secured from late season applications of calcium arsenate dust for the control of the cotton boll weevil. J. Econ. Ent. 17(4):477-480.

The cotton boll weevil causes severe damage to late fruiting cotton after the beginning of migration. Serious injury (causing poison to be required) did not

occur in the majority of fields until August 19 or later. The average increase in yields of seed cotton resulting from the use of calcium arsenate dust on comparable plots was 236 lbs. per acre. The average expense of using the calcium arsenate dust method was the cost of 29.27 lbs. of calcium arsenate and 3.6 hours of labor.

1924 - Smith, G. D. Further experiments with the Florida method of boll weevil control. Fla. State Plant Bd. Q. B. 8(2):27-72, 9 fig. Jan. Gainesville.

During 1923 further experiments were made with the Florida Method of control for the cotton boll weevil, particularly with regard to weather conditions and with a view to finding a method that would give quicker mortality.

1924 - Smith, C. M., and S. B. Hendricks. The determination of free calcium hydroxide in commercial calcium arsenate. Indus. and Engin. Chem. 16(9):950-951. Sept. Wash.

A method that has been devised for estimating the quantity of free lime present in calcium arsenate, as used for control of the cotton boll weevil, is described in detail.

The results, shown in tables, give the quantity of calcium hydroxide present, with an average error of about 0.02%. The results obtained from commercial samples were practically as satisfactory as those obtained when mixtures made from pure compounds were used. This method does not work so smoothly in the presence of magnesium compounds, and as commercial calcium arsenate sometimes contain a sufficient amount of them to affect the results, it is hoped to modify the method to include products containing them.

1925 - Anonymous. Insect pests. Tenn. Agr. Expt. Sta. 1924 Rpt. 37:27-31, 9 fig. Knoxville.

The Mexican bean beetle and the cotton boll weevil are the two most serious insect pests in Tennessee; the use of sodium fluosilicate and hydrated lime (1:9 by volume) for dusting against them has already been noticed.

1925 - Armstrong, G. M., R. W. Moreland, and R. C. Gaines. Progress report on studies on boll weevil control under South Carolina conditions. S.C. Agr. Expt. Sta. B. 223, 64 p., 25 fig. June.

Calcium arsenate dust, applied after 10% of the squares were found to be punctured by the weevil, resulted in 2.6 times the increase of seed cotton that was produced by the Florida Method, 3.1 times that with 1 pre-square application of molasses mixture, 1.6 times that with molasses mixture applied with mop and sprayer, and 2.2 times that with molasses mixture applied with a mop throughout the season. Early applications of molasses mixture and early applications of calcium arsenate dust, both of which were followed by calcium arsenate dust after 10% infestation, induced practically the same increase of seed cotton as calcium arsenate dust applied after 10% infestation. One pre-square application of molasses mixture, followed by calcium arsenate dust after 10% infestation, produced 2.2 times the gain of seed cotton that was made with 1 pre-square application of calcium arsenate dust alone. Molasses mixture applied with both mop and sprayer and nicotine dust made practically the same increase of seed cotton.

1925 - Grossman, E. F. A preliminary report on how the cotton boll weevil takes up poison. J. Econ. Ent. 18(1):236.

The cotton boll weevil receives the poison accidentally on the tip of the proboscis, and later, when chewing or moving its mandibles, the poison is introduced into the intestine. Sprays are less efficient than dusts because as the spray dries it forms a varnish-like film of poison, which does not adhere to the proboscis of the weevil crawling over the poisoned area, whereas loose particles of dust do so readily.

1925 - Marcovitch, S. Non-arsenicals for chewing insects. J. Econ. Ent. 18(1):122.
Sodium fluosilicate, undiluted, was effective in cage tests against the cotton boll weevil.

1925 - Nickels, C. B. Poisoning the boll weevil in the Piedmont Section of South Carolina. S.C. Agr. Expt. Sta. C. 33, 39 p., 8 fig. Feb. Clemson.
The cotton boll weevil as it occurs in South Carolina where, since its introduction in 1917, it has become the most serious pest of cotton. Many experiments in poisoning are described. The damage done in different seasons is very variable, amounting sometimes to 75% of the crop. The loss depends upon many factors; early maturing varieties are, as a rule, less subject to injury than later ones. When weevils are not particularly abundant, it is frequently difficult to decide whether poisoning is worthwhile. As a general rule it is considered that if the crop promises to yield as much as 1/3 of a bale to the acre, and severe infestation is noticed before maturity of the crop, a satisfactory profit would be derived from applications of calcium arsenate dust. These applications should begin as soon as boll weevil injury is observed on as many as 10% of the squares and should be continued as long as new squares are being developed.

1925 - Starr, S. H. Boll weevil control tests. Ga. Coastal Plain Agr. Expt. Sta. 5th Ann. Rpt. 1924, B. 5:19-21. June. Tifton.
Owing to the hot dry season of 1924, which exerted considerable natural control over the boll weevil, the increase in crop resulting from the use of insecticides was not so great as in the previous year, which was wet. Very good results have, however, been obtained by applying with a hand mop a syrup consisting of 3 lbs. calcium arsenate, 1 U.S. gal. molasses, and 3 U.S. gal. water to the growing points of the cotton plants 7 to 10 days before the first squares appear, repeating the treatment 2 or 3 times at weekly intervals, and subsequently dusting with calcium arsenate. The syrup would probably be more effective with an increased proportion of molasses, if this did not add too much to the cost.

1925 - Youngblood, Bonney. Entomology. Tex. Agr. Expt. Sta. 1924-25 Rpt. 38:19-24. Col. Sta.
"Cotton boll weevils . . . that emerged from hibernation in the spring were observed in connection with the ingestion of poison. The insects never groom themselves with their rostrum, but use their legs for the purpose. When a weevil moves about on glass or leaves that have been dusted with poison, the tip of its rostrum quickly becomes covered with dust, and particles of dust may be picked up by the mandibles, which work continually; even if it is well fed, paralysis and death occur in 3 to 8 hours. In cages where entire plants were dusted, 27% of the weevils were killed in 24 hours, and 88% in 5 days. In cages in which the squares and bolls were enclosed in paper bags before the plants were dusted, 13% and 52% of the weevils were killed in 1 and 5 days, respectively."

1926 - Hinds, W. E. Progress in cotton boll weevil control. J. Econ. Ent. 19(1):112-121.
In the cotton belt of the United States, the loss in cotton yield due to the cotton boll weevil in the past has averaged from 20% to 40% of the normal production, representing a very large increase in the cost to the consumer. As a result of concerted action by all parties concerned, however, and owing to the establishment of a safe and dependable program for cotton production and weevil control, a permanent system of agriculture for the cotton belt is now being followed, involving the continued production of cotton on a more economic basis, insurance of a fair profit to the grower, and more reasonable prices of cotton products for the consumer. Dusting by aeroplanes has given excellent results in trials and will probably become an important method of control in the near future.
Aphis gossypii, which is frequently very abundant, can be controlled at the same time as the boll weevil by adding to the calcium arsenate dust nicotine sulfate in the proportion of 94 parts (weight) of calcium arsenate with 6 parts nicotine sulfate (40%), that is, practically 1 lb. calcium arsenate to 1 oz. nicotine sulfate. Over 98% of the aphids are destroyed by an application of 8 - 9 lbs. of the dust per acre.

1926 - Hinds, W. E. The "cloud drift" versus the regular method of dusting. J. Econ. Ent. 19(4):607-608.

Only the abstract of this paper is published; it describes briefly the method of dusting cotton known as the "cloud drift" as a remedy for the boll weevil. By this method at least, part, of the dust cloud is thrown relatively high in the air above the cotton plant and then drifts slowly across the field, spreading a fairly even distribution of poison over a number of rows beyond those covered directly by the dusting machines. The rate of dust discharged is increased so that the actual amount of poison applied to an acre is practically the same as by the usual methods of application.

Experiments in Louisiana have shown that the gain of seed cotton to an acre due to regular dusting by the ordinary method was 501 lbs., or 64% over the average untreated yield, while the gain due to the cloud drift method was 599 lbs., or 77%. The "cloud drift" method, however, will be limited in its usefulness by the narrow range of atmospheric conditions within which it can be applied, but when favorable conditions occur and the direction of the drift is across the rows, half the time required for the usual method of dust application can be saved.

1926 - Howard, L. O. Report (1925-26) of the entomologist. U. S. D. A. Bur. of Ent., 30 p. Wash.

"Against the cotton boll weevil . . . investigations on the attractive properties of certain constituents of the cotton plant have been continued and certain dilutions of trimethylamine and ammonia have also proved attractive in laboratory tests; the value of these in practical field use is to be determined. While it is expected that several hundred thousand acres of cotton will be dusted by aeroplane, special attention has been given to the development of motor-operated high air-velocity machines for ground dusting."

1926 - Lyle, Clay. The cotton hopper. Miss. State Plant Bd. Q. B. 6(2):1-4, 1 fig.

"If the boll weevil is also causing serious damage, a dust of 2 parts superfine sulfur and 1 part calcium arsenate, 12 lb. to the acre, can be used to control both pests."

1926 - Marcovitch, S. Supplementary investigations of the fluosilicates as insecticides with observations on the effect of heat and drought on the Mexican bean beetle. Tenn. Agr. Expt. Sta. B. 134, 13 p., 1 fig., 8 ref. Jan. Knoxville.

Fluosilicates, sodium fluosilicate, and calcium fluosilicate have been produced on a commercial scale. Two brands of the former, known as "light" and "extra-light," are mixed with 15-20% and 25-30%, respectively, of alumnia. The "extra-light" mixture, when undiluted, is sufficiently toxic for many insects, but is not of much value against insects that feed sparingly, such as the boll weevil; it does not, however, cause foliage injury to beans, cotton, or cucumbers, although it seriously injures tobacco.

1926 - Osburn, M. R. Comparative tests with sodium fluosilicate and calcium arsenate for the control of the cotton boll weevil. J. Econ. Ent. 19(4):643-644.

In these tests against the boll weevil, equal field plots of cotton were treated with 5 lbs. an acre of calcium arsenate and with 10 lbs. an acre of sodium fluosilicate, which is heavier; other plots were left untreated. In cage tests, the sodium fluosilicate apparently acted as a repellent, as well as an insecticide, for weevils tended to collect on the side of the cage after dusting. Actual feeding was not necessary to produce killing, as weevils getting the poison on their feet brushed it off on the mouth parts, and, when placed on poisoned leaves, they died within a few hours without having fed on the leaves.

Sodium fluosilicate was more effective than calcium arsenate, and became effective in less than half the time. An average control of 80% was attained in 24 hours, while 48 hours were necessary for a mortality of 69% with calcium arsenate. The rapidity of effect is an important factor in rainy weather, as it may obviate the necessity of redusting almost immediately. There was very slight evidence of scorching on the more tender foliage, but not enough to make any attempt to dilute the sodium fluosilicate worthwhile.

1926 - Robinson, J. M. Dusting cotton with calcium arsenate for boll weevil control (P. R.). Ala. P. I. Agr. Expt. Sta. C. 51, 12 p., 3 fig. May. Auburn.

Details of tests made in 1924 and 1925 for the control of the cotton boll weevil in Alabama. The preliminary tests in 1924 gave sufficient evidence to show the superior value of calcium arsenate dust over the sweetened poison, so that all further tests should begin when the infestation reaches 10%. Three applications made at intervals of 4 to 5 days should be sufficient. An application just before the cotton begins to square is advisable when there are 20 or more weevils per acre. The infestation can be determined by counting all the squares on the plants until 100 is reached; the number of punctured squares among these will give the percentage of infestation. If infestation is below 10%, there is little or no advantage in dusting. About 6 lbs. calcium arsenate to an acre are required for 1 application.

Average increases in yields from dusting in 1924 was 204 lbs. of seed cotton per acre. Average cost of dusting per acre was $5.00. Thirty-six pounds of calcium arsenate is enough for dusting 6 times.

1926 - Sanborn, C. E. Boll weevil in Oklahoma, especially during the years 1921 to 1925. Oklahoma Agr. Expt. Sta. B. 157, 32 p., 10 pl., 4 fig. Feb. Stillwater.

A good deal of the information contained in this bulletin on the cotton boll weevil was given in a previous circular. Later tests have proved that dusting with calcium arsenate is not a satisfactory method of control in Oklahoma. The profit accruing from the use of the various methods has been worked out and is shown in tabular form. The materials tested included molasses-arsenate, nicotine-sulphate and calcium-arsenate, Hill's mixture, and poisoning by the Florida Method. For Oklahoma conditions, the best is the molasses-arsenate, consisting of 1 U.S. gal. of good table brand of syrup, 1 U.S. gal. water, and 1 lb. calcium arsenate, thoroughly mixed and used fresh, and splashed onto the plants with a mop. About 1 U.S. gal. of this mixture to the acre was used at each application, the treatments being given at intervals of about 7 to 10 days, beginning after infestation reached 10% to 15%.

1927 - Anonymous. Entomology. Tex. Agr. Expt. Sta., 1926 Rpt. 39:28-31. Col. Sta.

In order to study the ingestion of poison by the cotton boll weevil, field applications of calcium arsenate dust were made to cotton in the morning when a heavy dew was present, using 10 lbs. an acre. Analysis of the dusted buds and of 430 boll weevils killed by the poison showed that it would be necessary for a weevil to devour all the poison present on a bud or equivalent surface to obtain a fatal dose. The indications are that weevils obtain the greater part of the poison that kills them by the adherence of small particles of dust as they travel over the plant, and that 60% of them die from poison so obtained. The degree of mortality of weevils on hairy varieties of cotton is, therefore, to be compared experimentally with that obtained under similar conditions, upon less hairy ones.

"As a test of the efficacy of aeroplane dusting for Anthonomous grandis, 11,200 lbs. of calcium arsenate were distributed in 3 applications at an average rate of a little more than 9-1/2 lbs. an acre for each application. The yields are not yet complete, but the indications are that the poison used was effective in reducing damage by the boll weevil."

1927 - Anonymous. Las plagas del altodonero (Pests of the cotton plant). Mex. Sec. Agr. y Fomento. Mens. Defensa Agr. B. 1(2):70-84, 1 map. June. S. Jacinto, D. F.

Anthonomus grandis Boh., as cotton pest of many years' standing in Mexico, now appears to be satisfactorily controlled by the dusting of calcium arsenate from aeroplanes.

1927 - Folsom, J. W. Calcium arsenate as a cause of aphis infestation. J. Econ. Ent. 20(6):840-843.

In dusting with calcium arsenate for the control of the cotton boll weevil in Louisiana, it was observed that excessive applications of this dust were often followed by heavy infestation of Aphis gossypii Glov. Experiments to discover the

cause of this showed that the initial infestations were due to phototropic reaction of the winged female to a white dust, infestation being induced not only with calcium arsenate but also with calcium carbonate, starch, or flour. Plants dusted with calcium arsenate, colored green, remained uninfested. The fact that infestation becomes more intense on small areas of dusted cotton than in large ones is accounted for by the lack of opportunity for selection afforded to the aphids in the latter case.

1927 - Walker, H. W., and J. E. Mills. Chemical warfare service boll weevil, Anthonomus grandis, investigations (P. R.). Indus. & Eng. Chem. 19(6):703-711.

Preliminary tests have been made on more than 1,000 poisons or poisonous mixtures against the boll weevil, and about 50 of these have shown a toxicity equal to or greater than calcium arsenate. About 20 of these materials show little or no injury to the cotton plant. A total of 100,000 weevils were used in the tests made.

Barium, lead, zinc, mercury, and, to a lesser extent, iron, have shown some measure of toxicity to the boll weevil when combined with other chemical groups in themselves harmless, and the toxicity of these metals seems, in general, to be retained when combined with arsenic, and to increase the toxicity of the resulting arsenical. Sodium fluosilicate, barium floride and cryolite seem to be as effective as calcium arsenate, measured by volume. These substances should be subjected to further careful and extensive field tests to determine their exact value, using 10% to 15 lbs. to an acre. Every effort should be made to lessen the density of these poisons so that the amount per acre used can be decreased.

It is believed that an advantage will be gained if the percentage of arsenic in calcium arsenate is reduced and a larger amount used per acre. Arsenic trioxide or arsenic pentoxide, in relatively small percentages, absorbed on coal dust or some similar vehicle, may make an effective economical poison against the boll weevil if some agent such as oil be used to prevent scorching. Only occasional scorching is produced by 1-1/2% arsenic trioxide on coal dust at the rate of 10 to 15 lbs. an acre. The weevil seems to get most of the poison by more or less accidentally coming into contact with the dust particles and subsequently taking them into its system, but it does obtain some poison through its food and drink.

High concentrations of toxic gases are ineffective against the weevil, owing to its apparent ability to suspend breathing. There may still be a possibility that low concentrations of a persistent cumulative gas on absorbents may give effective control. The amount of arsenic in the best available form (soluble As_2O_3) necessary to poison a weevil is estimated as 0.0025 cc (2.5 mg.) and the air breathed by a weevil in an hour is roughly estimated as 0.46 cc.

The work emphasizes the need for careful management of dusting machinery so as to obtain an even distribution of the poison over the plant. A calm or a very slight wind is a necessity. The cotton plant should be moist if calcium arsenate is used. For the time being it is recommended that the method of control as described by the Southern Agricultural Workers Association, using calcium arsenate as a dust, or in special cases of a syrup mixture, be strictly adhered to.

1928 - Anonymous. Entomology. Tex. Agr. Expt. Sta., 1927 Rpt. 40:36-41. Col. Sta.

Findings that 70% of the cotton boll weevil are killed as a result of collecting the particles of calcium arsenate dust from the surface of the leaves and stems and that only 30% obtain it from feeding on squares and bolls.

1928 - Eddy, C. O. Cotton flea hopper studies of 1927 and 1928. S.C. Agr. Expt. Sta. B. 251, 18 p., 3 fig., 6 ref. Oct. Clemson.

"In addition to control measures already noticed, a mixture of 2 lbs. sulfur to 1 lb. calcium arsenate is recommended for use in fields infested with the boll weevil . . . as well as Psallus seriatus Reut."

1928 - Hamner, A. L. Predicting serious cotton aphids infestation. J. Econ. Ent. 21(5):736-741.

Serious infestations of the cotton aphids have occasionally followed applications of calcium arsenate against the boll weevil, and a rapid increase has been

seen in such infestations after they reach 10% of the cotton crop. The results of experiments in 1927 indicate that when an infestation as high as 5% exists at the time calcium arsenate dusting is started, a heavy aphid infestation may be expected after 4 applications are made.

1928 - Grossman, E. F. How the boll weevil ingests poison. Fla. Agr. Expt. Sta. B. 192:147-172, 6 fig., 18 ref. Jan. Gainesville.

A detailed account of experiments on the poisoning of the cotton boll weevil with calcium arsenate, many of the results of which have already been noticed. Plots treated with a mixture of equal quantities of calcium arsenate and hydrated lime yielded as much seed cotton to the acre for 3 consecutive years as those treated with undiluted calcium arsenate.

The weevil has not been controlled by taking advantage of its chemotropic, phototropic, or death-feigning activities. A characteristic dipping of the snout brings the mouth parts of the weevil in contact with surfaces over which it is crawling. There is no indication that the H_2O drinking habit of weevils is an important factor for successful distribution of calcium arsenate since there is no appreciable difference in mortality among weevils exposed to either wet or dry poisoned plants. Use of syrup mixtures for spraying is not recommended, but are useful for mopping on small cotton plants.

1928 - Robinson, J. M. Entomology--thirty-seventh and thirty-eighth annual reports. Ala. Agr. Expt. Sta., 1925-1926:21-22 and 23-24. Auburn.

Studies on the control of the cotton boll weevil with calcium arsenate dust. On heavy red clay soil two series of plots were used, one on old ground and the other on newly cleared ground. Five applications of dust were made. One was washed off within 24 hours, and the fifth, according to the infestation record, was unnecessary. The gains were 90 lbs. of seed cotton on the old ground and 150 lbs. on the newly cleared area, but these were not sufficient to make dusting profitable. On "black belt" clay, 9 applications of dust were made throughout the season, 3 of which were washed off within 25 hours. The gain was 300 lbs. of seed cotton per acre on the dusted plots. On sandy loam plots the tests were carried out to determine the effect of dusting on plots of cotton fertilization up to 1,500 lbs. per acre on both dusted and undusted plots. Weevil infestation reached 13% on August 27. Three applications of calcium arsenate were made at intervals of 5 days. The gain due to dusting varied from minus 12 lbs. of seed cotton on the unfertilized plots to 204 lbs. on the plot receiving 500 lbs. of fertilizer and 420 lbs. on the plot receiving 1,500 lbs. of fertilizer. The average results for the three years of the experiment show that the increase in yield from dusting has been dependent on the rate of fertilization, and that poisoning for weevil control is not profitable unless other conditions are favorable for the production of a good crop.

1928 - Walker, H. W. The preparation of a special light sodium fluosilicate and its use as a boll weevil poison. J. Econ. Ent. 21(1):156-164.

Two serious objections to the use of commercial sodium fluosilicate as a poison for the boll weevil are its lack of covering power, due to its comparatively high apparent specific gravity, and its toxicity to plants. These have been overcome by incorporating from 10% to 20% colloidal silica with sodium fluosilicate during the commercial process of manufacture.

The resulting special light sodium fluosilicate, containing at least 80% Na_2SiF_6, causes no economic plant injury and is a quicker weevil killer than commercial calcium arsenate. Under certain field conditions, however, it does not adhere to the plant so well as calcium arsenate. This lack of adherence under extremely moist conditions can probably be overcome by the incorporation of a small amount of adhesive during the process of manufacture.

Barium fluosilicate similarly prepared is about as effective as the sodium salt.

1928 - Walker, H. W. The preparation of special calcium arsenates containing less than 40% arsenic as As_2O_5 and their use as boll weevil poisons. J. Econ. Ent. 21(1):165-173.

A special calcium arsenate containing only about 20% arsenic calculated as As_2O_5 was equally as effective as a control for the boll weevil as commercial calcium arsenate in extended cage and field tests. The material caused no plant injury.

This special calcium arsenate was prepared by heating precipitated chalk and white arsenic (As_2O_3) in the presence of excess air at a temperature of 650° C. (1202° F.) for about one hour. In this manner it was possible to prepare a calcium arsenate containing any desired percentage of arsenic as As_2O_5 up to 57.6%, the theoretical for normal calcium arsenate $Ca_3(AsO_4)_2$. The conversion from the trivalent to the pentavalent state is practically complete, and there is scarcely any free lime formed under these conditions. Any arsenic lost in this process is recoverable on a commercial scale.

The particles of the special calcium arsenate containing 20% arsenic as As_2O_5 consisted of an inert core of calcium carbonate covered with a coating of substantially 100% normal calcium arsenate.

This direct oxidation method of preparation is adaptable for arsenates other than calcium.

1929 - Bishopp, F. C. The bollworm or corn ear worm as a cotton pest. U. S. D. A. Farmers' B. 1595, 14 p., 12 fig., 7 ref. June. Wash.

"Where the cotton boll weevil (Anthonomus grandis) and H. obseleta occur together, dusting with calcium arsenate is effective against both. Paris green can be applied as a spray (1 lb. to 50 U.S. gals. water) or as a dust (1 lb. to 3 lbs. air-slacked lime), but it is liable to scorch the foliage. Lead arsenic is less toxic, and more expensive than calcium arsenate. Dusting should be carried out at night when the plants are covered with dew, and 2 applications at an interval of 7-10 days usually give satisfactory results. The intensity of infestation varies from year to year, and the actual number of applications should depend upon the abundance of eggs deposited after the first application."

An account is given of the use of maize as a trap-crop for protecting cotton, and it is pointed out that the former should be planted late enough to attract the moths when they are ovipositing. The moths then concentrate on the maize from considerable distances, and the larvae are so numerous that they destroy each other and only a few of the many individuals hatching on the silk of each ear reach maturity.

1929 - Coad, B. R., and R. C. Gaines. Poisoning the cotton boll weevil. U. S. D. A. Leaflet 37, 4 p. Apr. Wash.

Brief popular instructions for the application of calcium arsenate dust against the cotton boll weevil in the cotton belt of the United States.

1929 - Grossman, E. F. Diluted calcium arsenate for boll weevil control. J. Econ. Ent. 22(6):972-974.

Additional experiments conducted in 1928, in the control of the cotton boll weevil, with equal quantitites of calcium arsenate and hydrated lime, confirm a series of tests carried out during 1924-26. The four years' results are shown in a table. The average yield from plots of cotton dusted with diluted and undiluted calcium arsenate was about identical throughout, and, in view of the reduced cost of treatment with the diluted mixture and the fact that no mechanical difficulty is attached to its preparation, it is recommended for use.

1929 - Robinson, J. M., and F. S. Arant. Dusting cotton with calcium arsenate for boll weevil control. Ala. Agr. Expt. Sta. C. 53. May.

Average increase from dusting ranges from 258 to 312 lbs. of seed cotton per acre. Forty lbs. of calcium arsenate was the average needed for each acre per season. Dusting operation cost was $5 per acre. Control is profitable only when infestation exceeds 10% and when potential yield is 1/2 bale or more per acre. Treatments were successful on either wet or dry foliage.

1929 - Wallace, H. F. Boll weevil and plant lice poisoning work. Miss. Agr. Expt. Sta. B. 271:14-15.

In 1929, experiments were carried out in Mississippi to test the advisability of dusting cotton late in the season, for the control of the boll weevil and aphids. The dusts were applied on August 9, when the weevil infestation on all plots reached 100%, and again on the 16th of August at the rate of 14 lbs. per acre. Two dusts were used; one, a mixture of 8 parts calcium arsenate to one part tobacco dust. The dust containing nicotine sulphate resulted in an increased yield of 355 lbs. per acre over the untreated plots, and that containing tobacco dust, 259 lbs. Both forms of nicotine controlled aphid infestation, and the treatments resulted in an increased profit equivalent to about $15 per acre.

1930 - Anonymous. Entomology. Tex. Agr. Expt. Sta., 1928 Rpt. 41:42-49; 42d, 1929; pp. 41-47, 146-147. College Station. 1929-1930.

Experiments on the relative number of boll weevils killed by the calcium arsenate adhering to different parts of dusted cotton plants showed that 2.2% were killed on the stems, 13.2% on the squares and bolls, and 84.6% on the leaves.

1930 - Hinds, W. E. Calcium arsenate tests, 1929, a progress report on small-scale tests comparing boll weevil (<u>Anthonomus grandis</u> Boh.) control with Lucas' green cross calcium arsenate versus a "standard brand" of calcium arsenate. J. Econ. Ent. 23(4):672-676.

These 2 forms of calcium arsenate were tested in the field in various ways. The Lucas materials showed indications of some advantages in dusting qualities and in adhesion to cotton in spite of rains. It appeared to be slightly more efficient in reducing the percentage of squares attacked by the boll weevil in plots dusted with this material and in the yield of cotton secured from an average of the four treated plots. In cage toxicity tests where weevils were exposed for 24-hour periods on dusted plants, the Lucas material gave an average mortality of 58% for the 6 successive periods of 24-hour exposure while "standard brand" calcium arsenate gave an average of 38%. These results were from 3 series of tests.

1930 - Robinson, J. M., and F. S. Arant. Entomology. Ala. Agr. Expt. Sta., 1929-1930 Rpt. 41:30-32, 37.

Studies on the control of the boll weevil with calcium arsenate were continued in 1929. On the sandy loam plots the infestation was kept below 20% until the 3d of September by 3 applications beginning on August 12, which resulted in an increased yield of 46 lbs. of seed cotton per acre. On the untreated plots the infestation had reached 95%. The average increase in yield from dusting during the last 6 years was dependent on the time of planting, rate of fertilization, and the percentage of infestation. The yield of seed cotton was increased 42 lbs. per acre by dusting, alone, and 184 and 307 lbs. per acre with the addition of 500 and 2,000 lbs. of fertilizer, respectively.

On clay plots the infestation was 38% on the 18th of June. Three applications of calcium arsenate at intervals of 4 to 11 days reduced it to 20% and kept it below 20% until the 15th of July. During a second series of 5 applications, two of which were washed off by the rain within 24 hours, the infestation varied from 6 to 36% until the 6th of August. On the 10th of August a 9th application was made to protect the young bolls. On the untreated plots the infestation had reached 83%. The increase in yield was 223 lbs. of seed cotton per acre, and the average increase over the 6-year period was 252 lbs.

1931 - Roark, R. C. Use of economic poisons to safeguard crops. U.S. Daily, 1 p. July 20.

It is estimated that 5,000,000 U.S. gals. of petroleum oil, 30,000,000 lbs. of lead arsenate, and 30,000,000 lbs. of calcium arsenate (the last-named, largely against the cotton boll weevil) are used annually as insecticides.

1932 - Robinson, J. M., and F. S. Arant. Eight years of experimental work in boll weevil control on plots receiving different rates of fertilizer. J. Econ. Ent. 25(4):759-766.

Experiments in the control of Anthonomus grandis Boh. with calcium arsenate dust have been conducted in Alabama over a period of 8 years, 1924-31, on plots of cotton receiving different rates of fertilizer. Dusting was found to be necessary during 5 years of the test and unnecessary during the other 3. The date of the first 10% infestation varied from the 13th of June in 1927 to the 27th of August in 1926. Applications of dust were made during the day when the air was relatively calm.

There was little increase in yield from dusting the unfertilized cotton. The average gains from dusting were 246, 409, 396, and 365 lbs. of seed cotton per acre on the plots receiving 500, 1,000, 1,500, and 2,000 lbs. of fertilizer, respectively. The number of dustings per season varied from 3 to 11, with an average of 5.2, and the amount of calcium arsenate required per acre from 21 to 77 lbs. with an average of 36. The average annual cost of the dusting operation was approximately $5 per acre.

1933 - Marlatt, C. L. Report of the Chief of the Bureau of Entomology, 1933. U. S. D. A. Wash.

Conditions regarding the boll weevil are discussed, together with experiments for its control against cotton, chiefly by means of calcium arsenate dusts. Parasitism in Louisiana in 1932 averaged a maximum of less than 10%, of which 90% was due to M. mellitor, other species reared being the Pteromalids, Catolaccus incertus Ashm., and C. hunteri Cwfd., Eurytoma tylodermatis Ashm., and Eupelmus cyaniceps Ashm.

1933 - Reinhard, H. J., and F. L. Thomas. Ingestion of poison by the boll weevil. Tex. Agr. Expt. Sta. B. 475. July.

Approximately 65% of boll weevil mortality on dusted cotton occurred as a result of accumulation of poison on mouth parts and accidental ingestion. Failure of poison sprays seemed to be due to the facts that particles of poison are not uniformly distributed and particles adhere more closely to the plant surface than do dust particles. The presence of dust on the plants retarded crawling activities by 60% and reduced number of fruits visited by 50%. Presence of pubescence on stems not only retarded the movement of the weevil, but also caused the weevil to bring its beak into contact with poison particles more frequently. Average mortality among weevils on totally dusted plants was 90.4%. With free access to clean or undusted fruits, mortality averaged 65.4%.

1934 - Baerg, W. J., D. Isely, and H. H. Schwardt. Entomology. Ark. Agr. Expt. Sta. B. 312:34-38. Fayetteville.

Very early varieties of cotton, only, benefited by 30.9%, while late varieties gained by 120% from dusting against the cotton boll weevil.

1934 - Robinson, J. M., and F. S. Arant. Entomology. Ala. Agr. Expt. Sta. Rpt. 44:27-29. Auburn.

Studies on the control of the boll weevil with calcium arsenate dust were continued in 1932. Of 10 applications made during the fruiting season, 4 were affected by rain within 24 hours, the yields of cotton were slightly above the average for the past 6 years, and there was a definite increase on all fertilized plots that had been dusted. The increased yields from dusted cotton were 213, 128, 426, and 400 lbs. of seed cotton per acre on the plots receiving 500, 1,000, 1,500, and 2,000 lbs. of fertilizer per acre, respectively.

1934 - Strong, L. A. Report of the Chief of the Bureau of Entomology. U. S. D. A. Wash.

Infestation of cotton by the boll weevil was heaviest in Louisiana, Miss., and southern Arkansas. In dusting experiments in South Carolina equal proportions of hydrated lime and calcium arsenate at the rate of 8 lbs. per acre gave as good

results as calcium arsenate alone at 7 lbs. per acre. The results were not unsatisfactory when the proportion of hydrated lime was doubled and the rate was increased to 9 lbs. per acre. This mixture would be cheaper and would lessen the danger of arsenical injury to the soil and of infestations by aphids that often follow heavy applications of calcium arsenate.

1934 - Young, M. T. Field-plot tests for boll weevil control at Tallulah, Louisiana, during 1933. J. Econ. Ent. 27(4):749-756.

In 1933, 8 cotton fields were divided into comparable plots, of which one was untreated and the others dusted with various insecticides for the control of the boll weevil. All applications were begun as soon as 10% of the squares had become infested. They were repeated (between daybreak and 7:30 a.m.) at 4-day intervals, so far as weather conditions permitted. If heavy rain occurred within 24 hours of an application, the dust was considered ineffective and another application was made. Weekly records of the percentage of squares infested were begun as soon as the plants had 4 or 5 squares large enough to be punctured by the boll weevil and were continued until the average number of squares to a plant was less than 4 or 5. Yield records were based on pickings from selected areas from those parts of the plots least liable to be affected by the adjacent ones.

The following figures show the estimated yield of seed cotton in lbs. per acre from one field following 7 effective applications of various dusts: untreated, 792; calcium arsenate (at an average rate of 5.3 lbs. per acre in each application), 1,077; sodium fluosilicate (8-12 or 4-6 lbs. per acre), 727 and 657 respectively, with some scorching of foliage; cryolite (sodium fluoaluminate) (6 lb.), 781; barium fluosilicate (5.4 lb.), 823. In another field, calcium arsenate and Paris green (3:1), especially when wet-mixed, gave better results in some tests than calcium arsenate, alone, but tended to scorch the foliage. Calcium arsenate and copper arsenate (3:1 or 4:1) appeared to give very good control of A. grandis, but the yields were not so great as on the plot treated with calcium arsenate alone. The results of applying calcium arsenate with a combined cultivator and duster were variable and inferior to those of dusting with hand guns; this mode of application is nevertheless considered to offer some promise.

1935 - Anonymous. Ala. Agr. Expt. Sta. Rpt. 45:26-28.

E. L. Mayton and J. M. Robinson give further details of the effect of dusting with calcium arsenate, for the control of the boll weevil, on plots of cotton used for experiments, with different rates of application of a chemical manure. In 7 of the 13 years for which the manuring experiment was carried out, the infestation necessitated dusting. This resulted in an average increase of 352 and 55 lbs. of seed cotton per acre on the fertilized and unfertilized plots, respectively.

1935 - Gaines, R. C. Ann. meeting of the Cotton States Branch and of the Texas Entomological Society. J. Econ. Ent. 28(1):54.

Reports the development and emergence of boll weevils from buds of althea (Hybiscus syriacus). So far as is known, this is the first time that the boll weevil has been found breeding in a plant other than cotton and Thurberia (Arizona wild cotton) growing under field conditions. In field-plot tests for boll weevil control at Tallulah, La., M. T. Young of the U.S. Bureau of Entomology, obtained an average increase of 419 lbs. of seed cotton per acre over the untreated check plots from the use of calcium arsenate by the standard method. The gains ranged from 187 lbs. to 617 lbs. of seed cotton per acre, or from 28.6% to 72% over the respective check plots.

1935 - Strong, L. A. Report of the Chief of the Bureau of Entomology and Plant Quarantine. U. S. D. A. Wash.

Tests for the control of the boll weevil with dusts of thiodiphenylamine and sulphur, and with derris in inert carriers, gave promising results. Early morning applications of calcium arsenate were more efficient than those made at midday or in the evening. Equal parts of calcium arsenate and hydrated lime applied at the rate of 7 lbs. per acre gave as good control as calcium arsenate alone at the same rate.

1935 - Young, M. T. Boll weevil control with calcium arsenate on field plots in Madison Parish, Louisiana. U. S. D. A. Tech. B. 487, 24 p.

An account is given of field tests to determine the effectiveness of calcium arsenate dusts for the control of the cotton boll weevil. The tests took place from 1920 to 1934 in northeastern Louisiana, where conditions are favorable for the insect. Calcium arsenate was generally used according to the standard method, dusting being started when 10% of the squares were punctured and continued at 4 to 5-day intervals so long as was necessary to keep the weevils under control, particularly during fruiting period. Occasionally treatment was begun earlier and continued longer. From 4 to 17 tests were made every year. Test plots and control plots were alongside one another. The area for picking, after the outer rows had been rejected as a buffer, varied from about 0.2 to 0.5 acres.

The average quantity of calcium arsenate applied per acre in one application varied from 4.17 lbs. to 11.63 lbs. When it was necessary to start dusting early in the season, more applications were required. Over the period of 15 years, the average weekly infestation of cotton squares varied from about 10% in June, on both treated and untreated plots, to about 47.5% on untreated and 22% on treated plots in August. The average increase in yield per acre for the treated plots ranged from 10 lbs. in 1924 to 742 lbs. in 1926, with an average of 356 lbs. or 30.2% over the complete period. In a few cases treated plots yielded less seed-cotton than untreated ones.

Tests made in 1920 showed that for early, intermediate, and late infestations the average increase in yield of treated over untreated plots was 43.9%, 34.5%, and 32.8%, respectively. With later infestations more cotton was produced on both treated and untreated plots.

Tests in 1927 on cotton planted at the usual time on unflooded land, and planted late, after flood waters had receded from the fields, indicated that the older cotton was first attacked and the young cotton became heavily infested only when the weevils migrated. The average increase in yield of treated over untreated plots was greater on the cotton planted at the normal time.

In 1928 the average infestation of squares on untreated plots was 5.0% to 22.1% less in fields planted with cotton for the first time than in those that had also been planted with cotton in 1927. The percentage increase in yield of treated over untreated plots was 36.1% in the first case and 45.7% in the second.

In two special tests in 1932, dusting was begun much later, when migration was in progress and the infestation of cotton squares was about 88%. Upon completion of 7 weeks of treatment, infestation was about the same on undusted plots and 49% and 59% on the dusted ones. More calcium arsenate was used per acre as the plants were larger. The increase in yield due to dusting was 75.7% and 319.3%.

Dusting complete fields is more efficient than dusting separate plots, since the weevils tend to migrate into the latter from untreated fields. The average percentage increase in yield is closely correlated with the number of days that have a precipitation of 0.3 inches or more, from the 21st of June to the 19th of August, and to a lesser extent with the total precipitation during this period, and the minimum temperature of the preceding winter.

1936 - Strong, L. A. Report of the Chief of the Bureau of Entomology and Plant Quarantine. U. S. D. A. 121 p. Wash.

In cage tests of dusts against the cotton boll weevil, mixtures of calcium arsenate with Paris green at the rates of 3:1 and 9:1 were more effective than calcium arsenate alone; but in field tests, calcium arsenate alone gave better results than these mixtures or than derris with sulphur (1% rotenone), Thiodipheylamine with sulphur (1:9), and calcium arsenate with lime (1:1). In a part of South Carolina where infestation was not severe, the three best dusts tested in order of profitable returns in control were: calcium arsenate with lime (1:2) employed after the infestation had reached 10%; calcium arsenate with lime (1:1); and calcium arsenate alone. Lime mixtures reduce the danger of soil poisoning and heavy infestation with aphids. Experiments and experience over several years indicate that the germination of the seed and survival of the seedlings of cotton, maize, and soybeans are reduced in plots that have received heavy applications of calcium arsenate against the weevil.

1936 - Watts, J. G. Entomology and zoology. S.C. Expt. Sta. 1935-36 Rpt. 49:39-50. Dec. Clemson.

Out of 9 combinations of insecticides tested for the control of thrips on cotton, a dust of 10% Paris green and 90% dusting sulphur gave the greatest reduction in population and the lowest percentage of injured stalks; and it did not injure the plants. The resistance of different varieties of cotton to this insect, as measured by the percentage of injured stalks, is shown in a table and varied by 13.86%. The cotton flea-hopper (Psallus seriatus Reut.) was abundant during the season, and experiments showed that the addition of Paris green to the standard dusting sulphur (which is applied at the rate of 15 lbs. per acre) increased the killing power considerably. A dust of calcium arsenate and Paris green also gave better results; it was more expensive, but it controlled the boll weevil.

1936 - Young, M. T., and G. L. Smith. Field-plot and cage tests for boll weevil control. J. Econ. Ent. 29(1):105-111.

Tests with dusts against the boll weevil, at Tallulah, Louisiana, in 1933 and 1934. In the field tests, applications began as soon as infestation of the squares reached 10%; they continued at 4-day intervals. They were made at 7:30 a.m., while the cotton plants were wet with dew and the air calm. If heavy rain occurred within 24 hours, the treatment was discounted or repeated. In a comparison of calcium arsenate and hydrated lime mixtures and calcium arsenate, alone, both gave good results. The latter was somewhat superior and gave higher yields. Field and cage tests were comparable. The diphenylamine and sulphur, and derris-root dust mixtures, each, had very little effect on the percent of squares infested. Cage tests with both these mixtures had a higher degree of mortality of weevils than field applications. A calcium arsenate-copper arsenite mixture appeared to be superior to calcium arsenate in the field. In cage tests calcium arsenate alone produced a somewhat higher boll weevil mortality.

1937 - Bondy, F. F., and C. F. Rainwater. Boll weevil and miscellaneous cotton insect investigations. S.C. Expt. Sta. 1936-37 Rpt. 50:95-102.

In experiments against the boll weevil, in South Carolina in 1936, dust treatments applied 5 times gave control on fruiting cotton after the weevils had migrated from old to late cotton, about mid-August. Similarly good control was given by applications of 10.1 lbs. of a 1:2 mixture of calcium arsenate and lime per acre, 8.9 lbs. of a 1:1 mixture, or 8.6 lbs. calcium arsenate alone. Treatment was cheapest per 100 lbs. gain of seed cotton when the 1:2 mixture was used.

In 1937 there was no appreciable control from pre-square applications of mopping mixtures that contained calcium arsenate, water, and thickeners or carriers of sweets (molasses, sugarcane syrup, or maize syrup), or other materials (agar agar, casein, or blood albumen). In dusting experiments, calcium arsenate, alone, or mixed with lime or sulphur, was more effective than pyrethrum and sulphur (1:9), cryolite, or barium fluosilicate and talc (1:2).

1937 - Gaines, J. C. Tests of insecticides for cotton boll weevil and bollworm control using the Latin square plot arrangement and analysis of variance. J. Econ. Ent. 30(5):785-790.

The Latin square block arrangement with blocks of 0.05 acre was used in tests of dusts for the control of Anthonomus grandis Boh. and Heliothis armigera Hb. (obsoleta, F.) on cotton in Texas in 1936. This method eliminated the variation due to differences of soil and uneven distribution of the insects. The analysis of variance was used to interpret the data. The dusts were applied 10 times from the 10th of July to the 22d of August, and all treatments gave significant control. There was no significant difference in the control of A. grandis affected by 6.9 oz. of calcium arsenate, 14 oz. of calcium arsenate and sulphur (1:1), 6.9 oz. of calcium arsenate and Paris green (5%), and 6.6 oz. of calcium arsenate and lime (25%) per block, but, when the dosage of calcium arsenate was reduced 25% by the addition of lime, the toxicity to H. armigera was reduced. The average of the differences in percentage injury on plots receiving this treatment and the three others was 3.8%, and the average of the reductions in yield per block was 6.9 lbs.

1937 - Gaines, R. C. Tests for boll weevil control using Latin square plot arrangement, Tallulah, Louisiana. J. Econ. Ent. 30(6):845-848.

Experiments on the control of Anthonomus grandis Boh. with calcium arsenate dusts were made in Louisiana in 1936, using the Latin square arrangement. The plots, 4 of which were left untreated, 4 treated with calcium arsenate, 4 with calcium and lime (50:50) and 4 with calcium arsenate and sulphur (50:50) were artificially infested. Treatment of 7 lbs. per acre was begun on the 28th of July and continued at intervals of about 4 days until the 26th of August. On the 27th of July, the average percentages of punctured squares on the 4 groups of plots were 12.9%, 14.6%, 17.5%, and 14.4%, respectively. On the 10th of August, they were 50.4%, 16.9%, 25.4%, and 23.9%. Conditions were favorable to the increase of the weevils during July, but very unfavorable during August and September. There were considerably more blooms and bolls on all the treated plots than on the control plots, slightly more on those that received calcium arsenate and sulphur than on those that received calcium arsenate and lime, and most on those that received calcium arsenate alone. The height of the plants and the number of plants per acre were very uniform. The data on yield were analyzed by the method of analysis of variance. The plots treated with calcium arsenate, calcium arsenate and sulphur, and calcium arsenate and lime produced respectively 10.9%, 9.3%, and 6.9% more than the controls. All these differences were significant, but there was no significant difference in control between any two of the calcium arsenate treatments.

1937 - Smith, G. L., and A. L. Scales. Toxicity of a number of insecticides to three cotton insects. J. Econ. Ent. 30(6):864-869.

The following is substantially the authors' summary of dusting tests made in Louisiana in 1936 with various insecticides: Against Anthonomus grandis Boh., calcium arsenate was more effective than any of the insecticides tested, with the exception of cube (4.9% rotenone), Paris green, and mixtures of calcium arsenate and Paris green.

1937 - Strong, L. A. Report of the Chief of the Bureau of Entomology and Plant Quarantine, 1937. U. S. D. A., 98 p. Wash.

In connection with work on the cotton boll weevil, a survey is given of observations in various states on the effect of calcium arsenate on the soil. Continued applications on the Delta soil of Louisiana and Mississippi have not affected cotton production in any way, but excessive quantities were injurious to soybeans and cowpeas. In South Carolina, injury was most noticeable in light sandy soils of low fertility where abnormally large amounts had been applied. In Mississippi, the effect on different crops varied considerably with the soil types. Defoliation of the mature plants resulted in a great reduction of overwintering population of Anthonomus grandis. In tests carried out in August in Mississippi, dusting increased the yield by 288 lbs. of seed cotton per acre, this being due partly to the development of heavier bolls on plants that had not been defoliated.

1938 - Ewing, K. P., and R. L. McGarr. Sulfur and calcium arsenate for the Control of the cotton flea hopper and the boll weevil. J. Econ. Ent. 31(6):669-674.

Mixtures of calcium arsenate and sulfur, 1:1, 1:2, and 1:4 proportions, were tested in 1-acre field-plot experiments along with sulfur for cotton flea hopper control and with calcium arsenate for boll weevil control. The infestation records and bloom counts showed that the mixtures gave slightly better flea hopper control than the sulfur, but the difference was not great enough to overcome the experimental error between the plots or show consistent gains in yield. In the 1-acre experiments for boll weevil control, the bloom counts and yield records showed that the addition of sulfur to calcium arsenate, when the minimum average poundage of calcium arsenate was not below 4.66 lbs. per acre application (1:2 and 1:1 mixtures of calcium arsenate and sulfur), increased the fruiting and also the production of the cotton over that of calcium arsenate alone when used at the rate of 6.68 lbs. per acre application. The net profit was also greater from

these two mixtures. The infestation records, blooms, counts, and yield records each showed that the 1:4 mixtures, which averaged 2.54 lbs. of calcium arsenate per acre application, were not so effective in controlling the boll weevil as either of the other mixtures or calcium arsenate alone.

Two experiments were conducted for flea hopper and boll weevil control in which small plots (1/40 and 1/20 acre, respectively) were arranged in Latin squares. Where the flea hopper infestation was high and damage occurred over a long period (square 1), the 1:1 mixture and the 1:2 mixture of calcium arsenate and sulfur gave significantly better control than sulfur alone; but where the flea hoppers decreased rapidly after dusting began and caused only light damage (square 2), the sulfur-arsenical mixture gave no better control than sulfur alone. Apparently sulfur alone gives adequate flea hopper control when the infestation is low, while the sulfur-arsenical mixtures are more effective against high infestations. The 1:1 mixture of calcium arsenate and sulfur (rate of 7.8 lbs. of calcium arsenate per acre application) and the 1:2 mixture of calcium arsenate and sulfur (rate of 5.35 lbs. of calcium arsenate per acre application) in square 1, and calcium arsenate alone (rate of 8.22 lbs. per acre application) and the 1:2 mixture of calcium arsenate and sulfur (rate of 5.43 lbs. of calcium arsenate per acre application) in square 2 were equally effective in controlling boll weevils. The 1:4 mixture of calcium arsenate and sulfur (rate of 3.2 lbs. of calcium arsenate per acre application) was not so effective in controlling boll weevils as the insecticides just previously mentioned.

1938 - Gilmer, Paul M. A progress report on the control of boll weevils on sea-island cotton. J. Econ. Ent. 31(6):684-687.

The results of the season's work were consistent in that the dusted plots and fields uniformly showed the best protection from late injury to bolls and the largest increases in yields. Under conditions as they existed in 1937, the boll weevil could be controlled on sea-island cotton. Sea-island cotton seems to be more susceptible to arsenical injury than upland cotton. This is a serious problem, as a prolonged poisoning schedule appears necessary for weevil control. The soils used for sea-island production are the light sandy types, seriously deficient in potash and nitrogen, which are more subject to arsenical injury than the heavier types. It was noted that where the land was well fertilized the use of arsenicals did not cause sufficient shedding of leaves to reduce the number or size of the bolls.

1938 - Rainwater, C. F. Test of insecticides for control of the boll weevil, with and without untreated checks. J. Econ. Ent. 31(6):682-684.

In these experiments calcium arsenate was superior to 50-50 or 33-1/3 to 66-2/3 calcium arsenate plus lime for boll weevil control. There was no significant difference between calcium arsenate and 50-50 calcium arsenate plus sulfur for boll weevil control. The 10-90 pyrethrum plus sulfur and 33-1/3 to 66-2/3 barium fluosilicate plus talc showed very little, if any, value as insecticides for boll weevil control. No significant difference was shown between 36% cryolite and 33-1/3 to 66-2/3 calcium arsenate plus lime for boll weevil control. Owing to the influence of aphids that often follow the application of arsenical insecticides, yield records may not be reliable criteria for determining the actual effect of an insecticide on the boll weevil. The need of an insecticide that does not increase the aphid infestation or that will control the aphids along with the boll weevil is clearly demonstrated in these experiments.

1938 - Smith, G. L., A. L. Scales, and R. C. Gaines. Effectiveness of several insecticides against three cotton insects. J. Econ. Ent. 31(6):677-682.

Definite correlations are shown between net boll weevil mortality and the following physical and chemical properties of calcium arsenate: particle size, density, water-soluble As_2O_5 by the New York method, and molar ratio CaO/As_2O_5. There appeared to be no significant correlations between such physical and chemical properties of calcium arsenate as angle of slope, loose bulking value at constant weight and constant volume, total As_2O_5, water-soluble As_2O_5 by the

A.O.A.C. method, and free $Ca(OH)_2$. The effectiveness of both calcium arsenate and lead arsenate seems to vary inversely with the amount of carrier added. Calcium arsenate showed significantly higher net mortalities of boll weevils and cotton leaf worms than the 4 cryolites that were tested. There appeared to be a definite relation between net mortality and the amount of cryolite (Na_3AlF) in the various samples of cryolite. In general, treatments with highest percentages of toxicant caused the highest net mortalities of boll weevils and leaf worms, though none was effective.

1939 - Anonymous. Later than customary poisoning of boll weevils indicated as profitable in cotton production. Miss. Farm Res. 2(10):7.

Straight calcium arsenate gave better control of the boll weevil and cotton leaf worm than a mixture of half calcium arsenate and half hydrated lime.

Studies indicate that growers can wait until plants are large and fruiting heavily and punctures reach 10% to 25% before dusting is necessary.

1939 - Bondy, F. F. Early versus late poisoning and a combination of both for boll weevil control. J. Econ. Ent. 32(6):789-792.

Since dusting with calcium arsenate for the control of Anthonomus grandis Boh. on cotton is followed by injury on sandy types of soil and the occurrence of aphids in large numbers after several successive applications, efforts were made to overcome these disadvantages by reducing the quantity of the arsenical used. Previous experiments indicate that, under conditions of light damage, satisfactory and economical control could be obtained in South Carolina by using diluted calcium arsenate. In 1938 the value of diluted calcium arsenate and pre-square treatments (directed against weevils coming out of hibernation) was tested under conditions of moderately heavy damage.

Presquare applications to the terminal buds, made 3 times at intervals of 5 days, resulted in no appreciable increase in yield and were expensive, whether they were of undiluted calcium arsenate dusts and equal quantities of calcium arsenate and hydrated lime, or of mixtures applied with a mop--1 lb. of calcium arsenate and 1 gal. of water, with or without 1 gal. of molasses. Presquare applications of calcium arsenate and hydrated lime, or the molasses mixture, followed by 3 of calcium arsenate and hydrated lime, when the squares were large enough for oviposition, increased the yields only slightly, with negligible profit and at a high cost. The presquare molasses treatment increased the yield considerably, with comparatively high profits and low costs, when followed, after 10% of the squares were infested, by several dust applications of calcium arsenate or by equal quantities of the arsenate mixed with hydrated lime, sulphur, or calcium carbonate. In general, the late dust treatments, alone, gave the highest yields and profits at the lowest cost.

Undiluted calcium arsenate, applied when 10% of the squares were infested gave the best results throughout. On light sandy soils, however, where there is danger of soil injury, the presquare molasses treatment followed by late dusting with calcium arsenate and hydrated lime, which gave the next best average profit per acre, is recommended. Presquare treatments delay the date when 10% of the squares become infested, reduce the number of later dust applications, and, hence, reduce the danger of soil injury and of building up harmful infestations of aphids. The best late treatment, when there is danger of soil injury and no presquare treatments have been given, is the dust of calcium arsenate and lime, which had the lowest cost per 100-lb. increase of yield. The dust containing sulphur is advisable when the flea hopper (Psallus seriatus Reut.), tarnished plant bug (Lygus pratensis L.) or red spider (Tetranychus telarius L.) is abundant.

1939 - Gaines, R. C. Boll weevil control tests with calcium arsenates containing different percentages of water-soluble arsenic pentoxide. J. Econ. Ent. 32(6):794-797.

In cage and laboratory tests net boll weevil mortalities caused by intermediate (4.5% water soluble arsenic pentoxide) and high (10.5%) calcium arsenate did not differ significantly, but both differed significantly from the low (0.4%). In

field tests the average increase in yield for low calcium arsenate was 3.8 lbs. per plot, or 20.3%; for intermediate, 3.0 lbs., or 16.0%; and for high, 3.1 lbs., or 16.6%. The author's conclusions are that there was no significant difference between calcium arsenates containing low, intermediate, and high percentages of water soluble arsenic pentoxide.

1939 - Gilmer, Paul M. Control of the boll weevil on sea-island cotton. J. Econ. Ent. 32(6):802-805.

Sea-island cotton was heavily infested and severely damaged by the boll weevil in 1938. In experiments conducted at Tifton, Georgia, the following insecticidal treatments were tested against the weevil: Calcium arsenate applied at the rate of 6.5 lbs. per acre per application when 5% of the squares were infested (intensive dust series); calcium arsenate applied at the same rate when 10% of the squares were infested (standard dust series); and calcium arsenate, syrup, and water (5 lbs. to 1 to 40 gals.) applied at the rate of 15 to 25 gals. per acre throughout the season (sprayed series). All treated plots increased in yield over the untreated check plot, the treatments being effective in the order listed.

The dusted plots produced lint of No. 1 grade, valued at 25¢ a pound; the sprayed plots, No. 2 grade, valued at 22¢ a pound; and the check plot, No. 4 grade, valued at 18¢ a pound.

The gains in yield and the improvement in grade from weevil control resulted in an increased crop value, over cost of treatments, of about $10 per acre in the dusted plots and about $4 in the sprayed plots.

1939 - McGarr, R. L. Progress report on mixtures of calcium arsenate and sulfur for control of the boll weevil at State College, Mississippi. J. Econ. Ent. 32(6):792-794.

"Tests were made on small (one-tenth-acre) plots dusted with a 1:2 mixture of calcium arsenate and sulfur, a 1:1 mixture of calcium arsenate and sulfur, and calcium arsenate alone, each replicated 12 times for control of the boll weevil. The infestation records showed very little difference in the control obtained with the different insecticides. While the yield records showed no significant difference between the insecticides, the average gains and profits were slightly in favor of the mixtures over the calcium arsenate. Tests on large (two-thirds-acre) plots on which a comparison was made of results from a 1:2 mixture of calcium arsenate and sulfur and from calcium arsenate alone, on early planted cotton with calcium arsenate alone, on late planted cotton with heavy weevil damage in untreated plots, gave large gains and profits in both cases, with slightly better results from the mixture than from the calcium arsenate."

1939 - Rainwater, C. F. Experiments using several insecticides with and without wetting agents and stickers for boll weevil control. J. Econ. Ent. 32(5):700-703.

Experiments were carried out in South Carolina in 1938 in which several insecticides applied as dusts, both alone and in combination with different commercial wetting agents and adhesives, were compared with calcium arsenate dust for the control of <u>Anthonomus grandis</u> Boh. on cotton. It was desired to find a substitute for calcium arsenate, because it is thought to injure the soil, and severe infestation by aphids often develops when it is applied repeatedly.

The insecticides tested were two nicotine compounds. One contained nicotine bennite and the other, nicotine bentonite plus nicotine tannate, and two cryolite dusts. One was a finely ground, synthetic, cryolite containing 90.8% sodium fluoaluminate, of which 88% of the particles were less than 10 microns in diameter, and the other, a coarsely ground cryolite containing 78.3% of sodium fluoaluminate, of which 35% of the particles were more than 50 microns in diameter. A mixture of calcium arsenate and calcium carbonate without an adhesive or spreader was also tested. The dusting qualities of both cryolites were extremely poor.

Statistical studies of the data showed that none of the wetting agents and adhesives increased the effectiveness of the calcium arsenate or the nicotine compounds. A synthetic liquid adhesive and spreader (lethane) increased the

effectiveness of the fine cryolite and made it comparable to calcium arsenate. Nicotine compounds gave very little or no control. There was no significant difference between calcium arsenate and the mixture of calcium arsenate and calcium carbonate.

From these studies and from general observations made throughout the season, it appears that cryolite might be developed into a satisfactory substitute for calcium arsenate in the control of A. grandis, provided that its dusting qualities are good and that the percentage of sodium fluoaluminate is high.

1939 - Smith, G. L., A. L. Scales, and R. C. Gaines. Additional records on the effectiveness of several insecticides against three cotton insects. J. Econ. Ent. 32(6):798-802.

The New York method shows definite positive correlations between net boll weevil mortality and the percentage of water-soluble As_2O_5. Dose-mortality records with fifth instar cotton leaf worms showed that smaller doses of calcium arsenates were required if they contained a high percentage of water-soluble As_2O_5 than when they contained a low percentage, and the intermediate percentage fell between the high and low. Definite relations are also shown between the percentage of water-soluble As_2O_5 by the New York method and the net boll weevil mortality with calcium arsenate fractions prepared by means of a centrifugal air separator. Di-calcium arsenate was more effective against the boll weevil than either basic calcium arsenate or a commercial calcium arsenate. The addition of wetting agents to calcium arsenate, to derris, to derris-sulfur mixture, to sulfur, and to cryolites, did not appear to affect significantly the insect mortality resulting from use of these insecticides.

1940 - Bondy, F. F., and C. F. Rainwater. Investigations on the control of cotton insects. S.C. Expt. Sta. 1939-40. Rpt. 53:121-127. Clemson.

The development, since 1923, of work on the control of Anthonomus grandis Boh. on cotton in South Carolina is briefly reviewed. Experiments during 1928-40 showed that the most effective and profitable treatment was dusting the cotton with calcium arsenate at 5-day intervals after 10% of the squares became infested. The chief objections to this treatment were that it is expensive and requires special dusting apparatus, that it is often followed by infestation by leaf aphids (Aphis gossypii Glov.), and that it may cause injury to subsequent crops.

In South Carolina, however, no case of soil injury was observed during several years of investigations. Tests in South Carolina and Mississippi to determine the amounts of calcium arsenate that would cause injury on different types of soil showed that 200 lbs. per acre on light sandy soils results in some injury to cowpeas but that cotton is not damaged until 400 lbs. is applied. On heavier soils, 1,600 lbs. per acre caused no damage to cotton. Ordinarily, not more than 40 lbs. of calcium arsenate per acre would be needed per year for weevil control, and it was considered that the risk of consequent soil injury has been greatly exaggerated.

1940 - Eddy, C. O. Insect pests and their control. La. Agr. Expt. Sta. B. 323, 51 p.

Cryolite gave very little control of the boll weevil on cotton, but unlike calcium arsenate, caused no injury to growing rice in the year following application on cotton.

1940 - Gaines, J. C. Tests of insecticides for certain cotton insects during 1939. J. Econ. Ent. 33(4):684-688.

Tests were made at College Station, Tex., in 1939 to obtain information on the comparative effectiveness against the bollworm and boll weevil of a specially prepared calcium arsenate, a commercial calcium arsenate, and a synthetic cryolite. An infestation of the rapid plant bug that developed on one of the plots made it possible to obtain some information on the action of the arsenicals on this pest, also.

The special calcium arsenate, containing large particles and a high percentage of water-soluble arsenic pentoxide, gave a significantly better control of the

rapid plant bug than the commercial calcium arsenate. This poison gave a higher control of the boll weevil and a higher yield than the commercial calcium arsenate, but the differences were not significant. Calcium arsenate gave significantly better control of weevils than cryolite, but, under dry weather conditions which caused excessive shedding, this difference did not affect the yields. In a preliminary test sulfur-calcium arsenate mixture (2 to 1) applied at the rate of 15 lbs. per acre gave 89%, 39%, and 61% control of the flea hopper, rapid plant bug, and boll weevil, respectively.

1940 - Gaines, R. C. Insect pests and their control. La. Agr. Expt. Sta. B. 323, 51 p.
Tests in Louisiana confirm the view that an adequate number of applications of calcium arsenate dust remains the best method of controlling the boll weevil.

1940 - Gaines, R. C. Boll weevil control with calcium arsenates containing different percentages of water-soluble arsenic pentoxide. J. Econ. Ent. 33(4):682-684.
Calcium arsenates containing low, intermediate, and high percentages of water-soluble arsenic pentoxide by the New York method were tested against the boll weevil at 8 localities in 1938 and at 5 localities in 1939. The tests included 68 replications.
The average infestation during 1938 and 1939 in the plots treated with low was 18.9%, intermediate 17.6%, high 17.2%, and untreated checks 34.7%. The average yield in 1/60-acre plots treated with low was 24.1 lbs. per plot, intermediate 23.2 lbs., high 23.3 lbs., and untreated checks 19.6 lbs.
The differences between the infestations and the yields in the calcium arsenate-treated plots each differed significantly at the 1% level from the infestation and yield in the untreated checks, but there were no significant differences among the infestations and yields in the plots treated with the calcium arsenates containing low, intermediate, and high percentages of water-soluble arsenic pentoxide.

1940 - Gaines, R. C., M. T. Young, and G. L. Smith. Effect of insecticides used in boll weevil control upon aphids and mirids. J. Econ. Ent. 33(5):792-796.
Aphids usually increased in number following application of calcium arsenate. A larger number of aphids was found in plots treated with calcium arsenate containing 10.3% of water-soluble arsenic pentoxide by the New York method than in plots treated with calcium arsenate containing 0.5%, the number found in plots treated with calcium arsenate containing 4.6% falling between the other 2. Sulphur appeared to have little or no effect upon aphid infestations.
There was a definite correlation between aphid infestations and yields and between aphid infestations and effectiveness of insecticides against boll weevils in cages. The reduction in yields caused by aphids is of much importance. In 1 series of tests calcium arsenate was sufficiently effective to control light infestations of the tarnished plant bug and the rapid plant bug without the addition of sulphur to the dusting mixture.

1940 - McGarr, R. L. Progress report (1939) on mixtures of calcium arsenate and sulfur for control of the boll weevil at State College, Mississippi. Assoc. South. Agr. Workers Proc., 41:114.
Dusting with mixtures of equal parts of calcium arsenate and sulfur, or of 1 part calcium arsenate to 2 parts sulfur, was as satisfactory for boll weevil control as dusting with straight calcium arsenate.

1940 - Rainwater, C. F., and F. F. Bondy. Combination of insecticides for boll weevil and cotton leaf aphid control. Assoc. South. Agr. Workers Proc., 41:114.
Experiments were conducted near Florence, South Carolina, during 1939 to determine the effect of several combinations of insecticides on the control of the boll weevil and cotton leaf aphid, Aphis gossypii Glov. Calcium arsenate was combined with the following insecticides and diluents: (1) equal parts of nicotine bentonite, (2) equal parts of nicotine bentonite-tannate, (3) equal parts of sulfur to which 0.5% rotenone from derris was added, and (4) equal parts of Celite to which

0.5% rotenone was added. Three cryolites containing 92.3%, 83.4%, and 81.3% Na_3AlF_6, respectively, were each used alone and with the addition of 0.5% rotenone. Barium fluosilicate containing 75% $BaSiF_6$ was used alone and with the addition of 0.5% rotenone. Owing to the lack of a heavy boll weevil infestation, no uniformly outstanding results on boll weevil control were obtained. Striking results were obtained in aphid control.

1940 - Young, M. T., G. L. Garrison, and R. C. Gaines. Insecticides for boll weevil control. J. Econ. Ent. 33(5):787-792.

Experiments in Louisiana in 1939 with dusts for control of the boll weevil on cotton. Plots dusted early in the morning with calcium arsenate containing 4.6% water-soluble arsenic pentoxide by the New York method showed a significant decrease in infestation over plots dusted at midday and late in the afternoon, but there were no significant differences among the yields. All the plots showed highly significant decreases in infestation and significant increases in yields over the untreated plots. Calcium arsenate (3.5% water-soluble arsenic pentoxide) caused a highly significant decrease in infestation and increase in yield, as compared with the control, but the figures for cryolite mixtures containing 33.8% and 89.3% sodium fluoaluminate were not significant.

The stronger cryolite dust caused severe scorching of the foliage, but the addition to it of 1% Lethane spreader resulted in very light scorching and a significant increase in yield over cryolite alone. Calcium arsenate alone and mixtures of calcium arsenate with sulphur (1:1 or 1:2) were about equal in effectiveness; sulphur alone was less effective. The addition of 5% of an adhesive did not improve the control given by calcium arsenate.

Throughout the experiments the average quantity of calcium arsenate applied at each dusting ranged from 5.6 to 6.4 lbs. per acre, and the average quantity of cryolite, sulphur, and mixtures of calcium arsenate and sulphur applied at each dusting was approximately 15 lbs. per acre.

1941 - Ewing, K. P. Spraying versus dusting for boll weevil control. J. Econ. Ent. 34(4):498-500.

In tests conducted at Waco, Tex., in 1939 and 1940, a power sprayer with 3 nozzles per row was used in applying calcium arsenate and lead arsenate under 300 lbs. pressure to field cotton, in comparison with the standard dust applications for boll weevil control. The plots ranged in size from 1.47 to 2.66 acres. There were 3 replicates each year, each replicate being in a separate field.

In 1939, when there was a light weevil infestation, the plots sprayed with lead arsenate produced slightly more cotton than those dusted with calcium arsenate. In 1940, however, under conditions of heavy boll weevil infestation, calcium arsenate dust gave much better weevil control than calcium or lead arsenate spray and resulted in larger gains in seed cotton and greater profits.

1941 - Gaines, J. C. Tests of insecticides for boll weevil control during 1940. J. Econ. Ent. 34(4):505-507.

A special calcium arsenate containing large particles and a high percentage of water-soluble arsenic pentoxide, a commercial calcium arsenate, and a cryolite-sulfur mixture were tested against the boll weevil at College Station, Tex., and Tallulah, La. Records were also kept on the aphid populations at both locations and on the mirid population at Tallulah.

The two calcium arsenates were equally effective in reducing the weevil population, and there was little difference in yield. The calcium arsenates gave a significant control of weevils and increases in yields over the cryolite-sulfur mixtures. All insecticides gave significant control and increases in yields over the checks.

The special calcium arsenate contributed to higher increases in the aphid population, but apparently not enough to affect the yield. At Tallulah the mirid control was significantly better on the plats treated with the special calcium arsenate than on the plats treated with cryolite-sulfur mixture, but the population was low, causing little injury. The special calcium arsenate gave better control of mirids than the commercial form, but the difference was not significant.

1941 - Gaines, J. C. A factorial experiment comparing insecticides for control of cotton insects. J. Econ. Ent. 34(4):512-515.

Experiments to obtain information on the value of insecticides used in a schedule of applications for the control of all cotton insects.

All the dusts were applied in the early morning when the cotton was wet with dew, sulphur at the rate of 14.6 lbs. per acre on June 26 and July 9, and calcium arsenate, and mixtures of lead arsenate and clay (90:10) and natural cryolite and sulphur (85:15), at the average rate of 9.4 lbs. per acre 6 times at approximately 5-day intervals from July 24 to August 22. The last three dusts contained 41.7% and 29.2% total arsenic pentoxide and 76.5% sodium fluoaluminate, respectively. Infestation by A. grandis, injury by H. armigera, populations of P. seriatus, Adelphocoris rapidus Say, and Aphis gossypii Glov., and yields of cotton were compared on plots receiving no treatment, sulphur, each of the three stomach poisons, and sulphur followed by each stomach poison. All the stomach poisons significantly decreased infestation by Anthonomus and Adelphocoris and injury due to H. armigera, and significantly increased the aphid population and the yield. The cryolite and lead arsenate mixtures were more effective against H. armigera than calcium arsenate, but less effective against Adelphocoris, and were followed by fewer aphids. The arsenicals were more effective against Anthonomus than the cryolite mixture. On the basis of yield, all the stomach poisons were equally effective.

1941 - Gaines, R. C. Effect of boll weevil control and cotton aphid control on yield as shown in a factorial experiment. J. Econ. Ent. 34(4):501-504.

In 1940, factorial experiments were continued in Louisiana, in South Carolina, and at two localities in Texas to determine the effect on infestation and yield of cotton of treatment with calcium arsenate dust containing about 7% to 8% water-soluble arsenic pentoxide for the control of Anthonomus grandis Boh.; with a dust of nicotine sulphate and lime containing 3% nicotine against Aphis gossypii Glov.; and of a combination of the two. Applications of calcium arsenate at the rate of about 7 lbs. per acre were begun when the first blooms appeared on the cotton plants and were repeated at 5-day intervals; 11 effective applications were made at College Station, Tex., and 8 at the other localities. Nicotine dust was applied at 2-4 times at a rate of approximately 14 lbs. per acre.

Calcium arsenate alone caused significant reductions in infestation by A. grandis in all localities but the one in South Carolina. The number of aphids increased noticeably in all localities. The yields, however, increased appreciably only in Louisiana and at College Station. Nicotine dust did not affect either infestation by A. grandis or yield at any locality when used alone, but it caused perceptible reductions in aphids in all localities except in South Carolina, both when used alone and with calcium arsenate. The combined treatment reduced infestation by A. grandis significantly in all localities except South Carolina. It resulted in yields of 205, 95, and 80 lbs. of seed cotton per acre greater than plots treated with calcium arsenate alone in Louisiana, South Carolina, and at College Station. Yields were 20 lbs. per acre less at Waco, Tex. Only the first difference was significant.

1941 - Gaines, R. C., M. T. Young, and G. L. Garrison. Effect of different calcium arsenates upon boll weevils, cotton aphids, and plant bugs, and upon yields. J. Econ. Ent. 34(4):495-497.

Experiments were conducted in 2 fields to study the effect of 3 calcium arsenates containing different percentages (0.42%, 11.4%, and 16.5%) of water-soluble arsenic pentoxide upon the boll weevil, the cotton aphid, the tarnished plant bug, and the rapid plant bug, and upon the yield of seed cotton. The results were analyzed statistically.

In both experiments the infestation records indicated that the 3 calcium arsenates were equally effective against the boll weevil. In both experiments the calcium arsenates containing 16.5% and 11.4% of water-soluble arsenic pentoxide were followed by greater increases in cotton aphids and greater reductions in the tarnished plant bug and the rapid plant bug, as compared with the checks. The

calcium arsenate containing only 0.42% of water-soluble arsenic pentoxide caused an average increase in yield over the checks of 239 lbs. of seed cotton per acre; the one containing 11.4%, 220 lbs.; and the one containing 16.5%, 247 lbs.

1941 - Jones, S. E. The effect on insect control on the yield and quality of cotton prematurely killed by cotton root rot. Iowa State Coll. J. Sci., 16(1):82-84.

An account of investigations carried out in Texas in 1937-39, which showed that the low yield of cotton, from plants killed by root rot before the first normal picking, was not materially increased by controlling infestation by Psallus seriatus Reut., and Anthonomus grandis Boh. Control of the Capsid was effected by dusting with sulphur, and the weevil, with calcium arsenate. If, however, yield from the surviving plants in an affected field is sufficient for profitable cotton production and insects are damaging the crop, control measures should be applied against them.

1941 - McGarr, R. L. Cryolite and cryolite-sulfur mixtures for boll weevil control and their effect on the cotton aphid. J. Econ. Ent. 34(4):500-501.

A cryolite-sulfur mixture containing 29.7% of sodium fluoaluminate gave no control of the boll weevil, and one containing 34.6% of sodium fluoaluminate, very little control. Cryolite alone was about half as effective as calcium arsenate.

1941 - McGarr, R. L. Control of the cotton aphid and the boll weevil in 1940. J. Econ. Ent. 34(4):580-582.

In tests conducted at State College, Miss., in 1940, calcium arsenate and mixtures of calcium arsenate and sulfur for boll weevil control caused significant increases in cotton aphids. The addition of derris to these materials effectively controlled the aphids and held the populations at nearly the same level as the checks. There was practically no difference in aphid control from derris when mixed with regular calcium arsenate, derris mixed with micronized calcium arsenate, or derris and calcium arsenate mixed and then micronized. Nicotine and tobacco dust, when added to calcium arsenate, were not effective in preventing an increase of aphids.

Calcium arsenate and calcium arsenate-sulfur mixtures with derris gave good control of the boll weevil. There was no significant difference between these treatments and undiluted calcium arsenate under the conditions of this experiment where the weevil infestation was light.

1941 - Moreland, R. W., E. E. Ivy, and K. P. Ewing. Insecticide tests on the bollworm, boll weevil, and cotton leaf worm in 1940. J. Econ. Ent. 34(4):508-511.

In cage tests at Waco, Tex., in 1940, various insecticides and mixtures of insecticides as dusts were compared with calcium arsenate against the bollworm, Heliothis armigera (Hbn.), boll weevil, Anthonomus grandis Boh., and cotton leaf worm, Alabama argillacea (Hbn.).

When bollworm larvae were arranged into 4 weight groups, with one exception, mortalities due to insecticides varied inversely with the weight of the larvae. A mixture of basic copper arsenate and lime killed approximately the same percentage of large worms (over 45 milligrams) as calcium arsenate killed of small worms (under 15 milligrams). Against bollworm larvae of all weight groups, the average mortality, after 120 hours, was 91.8% from the basic copper arsenate and lime mixture, 87.9% from lead arsenate, 83.7% from undiluted basic copper arsenate, 82.7% from cryolite containing 66.1% of sodium fluoaluminate, and 62.3% from calcium arsenate.

Basic copper arsenate and mixtures of this material with lime and with sulfur gave somewhat higher kills of the boll weevil and the leaf worm than did calcium arsenate.

1941 - Rainwater, C. F., and Floyd F. Bondy. Combinations of insecticides for control of boll weevil and cotton leaf aphid. J. Econ. Ent. 34(2):297-300.

Experiments were conducted on 2 Latin squares consisting of 36 0.05-acre plots, each, and on 4 0.75-acre field plots near Florence, South Carolina, during 1939 to determine the relative effectiveness of several insecticides and combinations of insecticides for control of the boll weevil and the cotton leaf aphid.

Calcium arsenate, mixtures of equal parts of calcium arsenate and two fixed-nicotine dusts, and barium fluosilicate plus derris (to give a rotenone content of 0.5%) were significantly better than 2 of the 3 cryolites tested with or without the addition of derris for boll weevil control, when based on average seasonal infestation. Yield records and boll counts did not show significant differences between treatments.

The cryolites and barium fluosilicate with derris were inferior to calcium arsenate in dusting qualities but were followed by aphid populations of only 12% to 24% of those treated with calcium arsenate.

Equal parts of calcium arsenate and fixed-nicotine dusts held the aphid population to approximately 50% of that in the undiluted calcium arsenate treatments. Equal parts of calcium arsenate and sulfur, or of calcium arsenate and diatomaceous earth, with the addition of derris, gave satisfactory boll weevil control and kept the aphid population equal to or below that of the checks.

1941 - Rainwater, C. F., and Floyd F. Bondy. Boll weevil and cotton aphid control by the use of derris in combination with calcium arsenate. J. Econ. Ent. 34(6):733-735.

In identical experiments conducted at Florence, S.C., State College, Miss., Tallulah, La., and Waco, Tex., in 1940, 4 insecticides or combinations of insecticides were tested against the boll weevil and the cotton aphid, Aphis gossypii Glov. They were calcium arsenate, with and without derris, at the rate of 6 lbs. per acre per application and equal parts of calcium arsenate and sulfur, with and without derris, at the rate of 12 lbs. per acre per application. Eight effective applications were made at each location.

Analysis of the data showed that there was no significant difference in the degree of boll weevil control between any 2 insecticides and that each was significantly better than the check. Counts of aphid populations showed highly significant differences favoring the insecticides which contained derris over those which did not. Yield records showed that calcium arsenate plus derris was significantly better than calcium arsenate alone.

1941 - Smith, G. L., A. L. Scales, and R. C. Gaines. Further studies of various insecticides against three cotton insects. J. Econ. Ent. 34(2):310-313.

In cage tests conducted at Tallulah, La., in 1939, several arsenicals and cryolites were used against the boll weevil and the cotton leafworm, and derris, pyrethrum, sulfur, and calcium arsenate-sulfur mixtures against the tarnished plant bug.

With calcium arsenates that had been separated into fractions according to particle size, definite correlations were shown between particle size and percentage of water-soluble arsenic pentoxide as determined by the New York method, between particle size and net boll weevil mortality, and between percentage of water-soluble arsenic pentoxide and net mortality.

Calcium arsenate was more effective against the boll weevil and the cotton leaf worm than cryolite with or without wetting agents. Dicalcium arsenate gave better results than commercial calcium arsenates, calcium arsenate-sulfur mixtures, or basic copper arsenate. The addition of wetting agents to calcium arsenate and to cryolite did not significantly affect mortality. Calcium carbonate and sulfur appeared to be better carriers for calcium arsenate than lime.

1942 - Baerg, W. J., and D. Isely. Insect investigations at the Arkansas station. Ark. Agr. Expt. Sta. B. 428:36-41, 52-53.

Contains notes on spot dusting to control the boll weevil.

1942 - Becnel, I. J., and E. H. Floyd. Insecticide tests for cotton aphid and boll weevil control during 1941. J. Econ. Ent. 35(5):623-626.

To study the effect of Aphis gossypii Glov. on the yield of seed cotton, in a program for the control of the boll weevil, and to determine the effectiveness of several aphicides in combination with calcium arsenate, experiments were carried out in 1941 in 2 localities in Louisiana.

At one location, all the dusts significantly reduced boll weevil infestation over the control plots. Calcium arsenate and 1% nicotine, in the form of Black Leaf 10, resulted in much higher yields and lower aphid infestation levels than any other treatment. The reduction of boll weevils was similar to those on plots treated with calcium arsenate alone or with 10% sulphur and 0.5% rotenone (derris), and was considerably lower than on plots treated with calcium arsenate, 10% sulphur, and 0.2% pyrethrins in the form of Pyrocide (2% pyrethrins).

Boll weevil infestation was heaviest on the control plot and not significantly lower on those receiving calcium arsenate with sulphur and pyrethrins or rotenone, but significantly lower on plots treated with calcium arsenate alone or with nicotine. The plants treated with nicotine, which bore very low populations of aphids, kept their foliage considerably longer than plants on the other plots.

In the 2 experiments, calcium arsenate alone, with nicotine, with sulphur and rotenone, and with sulphur and pyrethrins resulted in average increases in yield of 323, 359, 168, and 258 lbs. of seed cotton per acre, respectively, over the control plots.

1942 - Bondy, F. F. Mopping, dusting, and combination treatments for boll weevil control in South Carolina. J. Econ. Ent. 35(4):498-499.

A total of 187 field experiments were carried out against the boll weevil at Florence, S.C., in 1928-41, to determine the comparative value of a mopping mixture of calcium arsenate, molasses, and water (1 : 1 : 1) applied to cotton in the pre-square stage, calcium arsenate dust applied after 10% of the squares had been punctured, and a combination of these 2 treatments. The average increases in yield over comparable untreated plots were 39, 286, and 331 lbs. of seed cotton per acre, respectively, with average net profits of $1.10, $9.60, and $11.40 per acre for the 3 treatments.

1942 - Ewing, K. P., and R. W. Moreland. Insecticides to control bollworm, boll weevil, cotton aphid, and cotton flea hopper. J. Econ. Ent. 35(5):626-629.

Basic copper arsenate mixed with sulfur or lime produced higher yields of cotton than calcium arsenate, lead arsenate, or cryolite in experiments for the control of the bollworm and the boll weevil. Yields were higher than from sulfur or sulfur-arsenical mixtures in experiments for the control of the flea hopper.

The increase in aphids that followed dusting with basic copper arsenate and sulfur was less than half as great as that which followed dusting with calcium arsenate or zinc-safened calcium arsenate. On cotton dusted with calcium arsenate there were 316 times as many aphids when 0.5% of rotenone was added as when 1% of nicotine was added. Calcium arsenate containing zinc sulfate showed little promise of holding down aphids.

1942 - Fenton, F. A., and K. S. Chester. Protecting cotton from insect and plant diseases. Okla. Agr. Expt. Sta. C. 96, 32 p., 13 fig., 1 ref. Stillwater.

Cotton should be planted early, for the number of weevils increases greatly as the season progresses. A dust of undiluted calcium arsenate should be applied to productive fields when 10% of the squares are infested and again 5 and 10 days later. Subsequent applications may be needed if the infestation again increases to dangerous proportions. The dust should be applied on a calm day at a rate of 4 lbs. per acre on young cotton and at 5 to 7 lbs. per acre on large plants, and the treatment should be repeated if rain falls within 24 hours.

1942 - Gaines, R. C. Effect of boll weevil and cotton aphid control on yields as shown in a factorial experiment in 1941. J. Econ. Ent. 35(4):493-495.

Factorial experiments in South Carolina, Florida, Louisiana, and Texas, in 1941, to determine the comparative effect of treatment with calcium arsenate dust for the control of Anthonomus grandis Boh., with nicotine against Aphis gossypii Glov., and of a combination of the two treatments on infestation and yield of cotton. The nicotine was applied in a spray at the rate of about 2 lbs. of nicotine sulphate (40%) per 100 U.S. gals. of water in Florida and in a dust of tobacco and lime (9:1) to which the nicotine sulphate was added to give a nicotine content of approximately 3% in the other States.

Comparison of the results from treatment with calcium arsenate or calcium arsenate and nicotine with results from no treatment or treatment with nicotine, only, showed that the arsenate caused significant reductions in weevil infestation in all localities, increases in number of aphids in all localities except in Louisiana, and increases in yield in all but Florida and Louisiana. The increase in yield in Texas was partly due to the control of the bollworm. Calcium arsenate gave significant increases in yield (391%, 64%, and 45%, respectively) over the control plots in South Carolina and Louisiana, where weevil infestation was heavy, and Texas, where it was intermediate. Nicotine gave nonsignificant increases in Florida, Louisiana, and Texas; and calcium arsenate and nicotine together gave significant increases of 418%, 128%, and 41%, respectively, in South Carolina, Louisiana, and Texas.

1942 - Roark, R. C. Insecticides for control of cotton insects. Chem. Engin. News 20:1169-1172.

Contains a list of the principal insects that attack the cotton plant in the United States and of the insecticides mainly used for their control, with the estimated annual consumption of each. Calcium arsenate is used chiefly for the control of the boll weevil, which is the most destructive pest and is estimated to destroy an average of 10% of the crop, but it is also recommended against the cotton leafworm and the bollworm. The chemical and physical composition of commercial and other calcium arsenates are discussed in some detail, with the rates at which they should be used and the methods of application.

Fluorine seems to be the most promising substitute for arsenic in insecticides. Reviewed are the results obtained in tests of insecticides with a special light sodium fluosilicate and a special calcium arsenate with a low arsenic content. Cryolite was shown to be effective against H. armigera but only half as toxic to Anthonomus as calcium arsenate. Ordinary calcium arsenate diluted with an equal weight of hydrated lime is effective against light infestations of the weevil. Paris green, when mixed with half its weight of calcium arsenate, is also of value against Anthonomus.

All these insecticides, with the exception of sulphur, are likely to become scarce in the United States, owing to war conditions; it is important that they should be applied as effectively and economically as possible.

1942 - Robinson, J. M., and E. L. Mayton. Yield in cotton due to control of boll weevil. Ala. Agr. Expt. Sta. 1941 Rpt. 52:27-32.

The results of experiments in 1924-41 in which the gain in yield of cotton, due to the control of boll weevil by dusting with calcium arsenate in years in which the amount of infestation required it, increased with the amount of fertilizer applied to the plots.

1942 - Smith, G. L., A. L. Scales, and J. A. Fontenot. Effect of insecticidal drift in small plots upon boll weevil and cotton aphid. J. Econ. Ent. 35(4):594-595.

Mortalities in the first row of the checks adjacent to treated plots were, in most cases, higher than in the third and fifth rows. Check plots having a treated plot adjacent on 2 sides had an average weevil mortality of 22.7% and 20.3%, as compared with average mortalities of 35.1% and 33.8% in check plots having treated plots on all sides. In the laboratory yard where the check cages were not near treated plants, the average mortality was only 17%.

The average mortality was 79.6% in 2 plots treated with the standard calcium arsenate, 67.6% in 2 plots treated with a mixture of standard calcium arsenate and derris, and 50.3% in 2 plots treated with a special calcium arsenate. In the laboratory yard average cage mortalities for the 3 treatments were 86%, 84%, and 85%, respectively.

1942 - Thomas, F. L., Clay Lyle, F. S. Arant, and Dwight Isely. Report of the committee on cotton boll weevil control, Proc. 7th Ann. Meet. of Cotton States Br., Amer. Assoc. Econ. Ent. J. Econ. Ent. 35(2):297.

In view of the evidence by research agencies, confirmed by practice in representative sections of the country, the membership of the Cotton States Entomologists reaffirm their confidence in the established methods of boll weevil control.

The most practical direct method is to protect cotton by dusting with calcium arsenate at the time when the plant is fruiting freely. Dust should be applied only when active injury is occurring, as determined by counts of infested squares. Local conditions should determine the details of recommendation which may be made by the entomologists in the States concerned.

Due to the World War II emergency, and the possible scarcity of arsenicals and equipment, it was recommended that special emphasis be placed on cultural methods of control. Such methods include early production, early fall destruction of cotton stalks where practicable, consolidation of fields, and stimulation of production by fertilization.

1942 - Young, M. T., G. L. Garrison, and R. C. Gaines. Experiments on time to begin dusting with calcium arsenate and number of applications for boll weevil control. J. Econ. Ent. 35(4):484-486.

To determine when dusting with calcium arsenate should begin and the number of applications necessary for the most economical control of the boll weevil on cotton in Louisiana, the yields obtained with applications at 4- or 5-day intervals, beginning when 10% of the squares were infested and continuing for as long as necessary, were compared with those from smaller numbers of applications, begun at different infestation levels and at the time of weevil migration from field to field, during the first week in August.

The average increases in yield of seed cotton per acre was 506 lbs., in 2 years of experiments, for 6 applications begun at a 10% infestation level, 196 lbs., for 3 applications before migration, and 292 lbs. for 3 applications begun at migration. In a series of single-year tests, 8 applications beginning with an 8% infestation gave an average increase of 522 lbs., 5 applications beginning at 25% infestation, an increase of 580 lbs., and 4 applications beginning with a 70% infestation a 350-lb. increase. When results of 2 experiments testing the effect of 6 and 5 applications starting at infestations of 30%-40% and 50%-60%, respectively, were combined, yield increases were nonsignificant. A single application beginning with migration gave a yield increase of 137 lbs., 2 applications, 239 lbs., and 3 applications, 256 lbs.

1942 - Young, M. T., G. L. Garrison, and R. C. Gaines. Boll weevil control with calcium arsenate applied at different times of day and at different time intervals. J. Econ. Ent. 35(4):487-489.

An account of 2 series of experiments carried out in Louisiana to compare the yields of seed cotton obtained when undiluted calcium arsenate was applied for the control of Anthonomus grandis Boh., at 4- or 5-day intervals between daybreak and 7 a.m., between 1 and 3 p.m. and 6 and 7:30 p.m., and when it was applied in the early morning at 4-, 6-, or 8-day intervals. During 1934-35 and 1938-41, applications made during the early morning gave an average increase of 308 lbs. per acre over the control plots, those near midday gave 311 lbs., and those during the late afternoon, 264 lbs. In 1934-41, applications at 4-day intervals gave an increase of 208 lbs. per acre over the control plots, those at 6-day intervals gave 143 lbs., and those at 8-day intervals, 100 lbs.

1942 - Young, M. T., G. L. Garrison, and R. C. Gaines. Calcium arsenate with and without aphicides for control of boll weevil and cotton aphid. J. Econ. Ent. 35(4):490-492.

In experiments against Anthonomus grandis Boh. and Aphis gossypii Glov. on cotton in Louisiana in 1941, undiluted calcium arsenate, zinc-safened calcium arsenate (3.4% zinc oxide, pH 10.5), mixtures of calcium arsenate and derris, cub or timbo (0.5% rotenone) and calcium arsenate mixed with nicotine sulphate solution to give nicotine contents of 0.5, 1% and 2%, or with a dust containing free nicotine to give 1% nicotine were equally effective against the weevil, giving significant control.

1943 - Ewing, K. P., and C. R. Parencia, Jr. Dosages of insecticides to control the boll weevil and the bollworm. J. Econ. Ent. 36(4):607-610.

Field-plot experiments were conducted at Waco, Tex., in 1942 to determine the effectiveness of reduced dosages of calcium arsenate against the boll weevil and whether cryolite could be substituted for calcium arsenate in its control. The comparative effectiveness of calcium arsenate, basic copper arsenate, lead arsenate, and cryolite against the bollworm were also studied. The boll weevil infestation was too light to show any marked differences in yield between plots treated with calcium arsenate, cryolite, and various dilutions of these materials with sulfur, for weevil control. However, 1 experiment did show that 3 dilutions of calcium arsenate reduced the weevil infestation to lower levels (average, 11.9%) than did similar dilutions of cryolite (average, 13.9%).

1943 - Gaines, J. C. Comparative tests of certain insecticides and variations in schedules for cotton insect control. J. Econ. Ent. 36(1):79-81.

Alternate applications of calcium arsenate and lead arsenate, using 2 applications of lead arsenate during the period when bollworm injury was highest, gave good control of both weevils and bollworms. When cryolite was substituted for lead arsenate, losses in yields occurred because of increased weevil injury. Two consecutive applications of either lead arsenate or cryolite at the peak of bollworm injury, instead of calcium arsenate, did not prove to be effective against the weevils, thus causing a loss in yield.

1943 - Gaines, J. C., and H. A. Dean. The relative effectiveness of calcium arsenates composed of large and of small particles. J. Econ. Ent. 36(1):76-78.

A special calcium arsenate containing large particles, a special calcium arsenate, sulfur, rotenone mixture, and commercial calcium arsenate were tested against the boll weevil, bollworm, and aphids at College Station, Tex., and against the boll weevil and aphids at Tallulah, La. Records were also kept on rapid plant bug populations at both locations, but the populations were low, and only small differences occurred between treatments.

The special calcium arsenate and commercial calcium arsenate were equally effective against weevils at both locations, but the coarse material (special calcium arsenate) did not give as good control of bollworms at College Station as the commercial calcium arsenate. Both materials contained approximately the same percentage of water-soluble arsenic pentoxide.

1943 - McGarr, R. L., and J. R. Henry. Insecticides tests for boll weevil and cotton aphid control in the Mississippi delta. J. Econ. Ent. 36(5):716-718.

An account is given of experiments carried out in 1942 on the control of Anthonomus grandis Boh. and Aphis gossypii Glov., on cotton in Mississippi, in which calcium arsenate and a mixture of calcium arsenate and sulphur (1:2) were applied alone or with nicotine sulphate or other aphicides; approximately 5% hydrated lime was added to the mixtures containing nicotine to insure its liberation. The dusts were applied at the rate of 6 to 8 lbs. per acre at intervals of 4 or 5 days when boll weevil infestation exceeded 15%-25% in the plot showing the best control, 4 to 6 applications being made between the middle of July and the middle of August.

Calcium arsenate with 2% actual nicotine in alternate applications and calcium arsenate with 1% in all applications gave satisfactory control of the weevil, kept the aphid infestation about the same as in untreated plots, and resulted in increases in yield of seed cotton of 415 and 394 lbs. per acre, respectively, in large-plot tests, and 323 and 318 lbs. per acre, respectively, in small plots, whereas calcium arsenate alone controlled the weevil but resulted in a loss of 138 lbs. per acre in the large plots and a gain of only 11 lbs. in the small ones. The yields for no treatment were 2,132 lbs. per acre in large plots and 1,912 in small ones. The differences in yield between the treatments with and without nicotine seemed to be largely due to aphid damage. In small-scale tests, calcium arsenate alone gave better control of Anthonomus than the mixture of calcium arsenate and sulphur, but resulted in the development of significantly more aphids, in the absence of aphicides.

1943 - Young, M. T., G. L. Garrison, and R. C. Gaines. Calcium arsenate with and without cube and nicotine for control of the boll weevil and the cotton aphid at Tallulah, Louisiana, in 1942. J. Econ. Ent. 36(6):901-903.

Two experiments indicate that poisoning with calcium arsenate for a light boll weevil infestation may result in reduced yield unless an aphicide is also used.

1944 - Annand, P. N., and others. Tests conducted by the Bureau of Entomology and Plant Quarantine to appraise the usefulness of DDT as an insecticide. J. Econ. Ent. 37(1):125-159.

(Ivy, E. E. - p. 142) A 2% DDT dust at a rate of 32 lbs. per acre, in the laboratory, was completely ineffective against Anthonomus grandis Boh.

1944 - Fife, L. C. Reduced dosages of calcium arsenate and cryolite for control of the boll weevil and their effect on the cotton aphid. J. Econ. Ent. 37(1):19-21.

The results are given of experiments in Texas in 1942 to determine the effect of reducing dosages of calcium arsenate and cryolite on the control of Anthonomus grandis Boh. and on Aphis gossypii Glov. The tests were made in fields planted about a month later than usual, and a general migration of the weevil from early to late fields began on 15th July, after which infestation rapidly increased in all plots, remaining high throughout the remainder of the season.

Only plots treated with calcium arsenate alone and with sulphur (1:2) showed significant reductions in infestation by A. grandis.

1944 - Gaines, J. C. Insecticide tests for bollworm control. J. Econ. Ent. 37(6):723-727.

Calcium arsenate proved profitable against the bollworm, but not as profitable as some of the other insecticides. Cryolite was effective against bollworms, but yields were reduced when weevils occurred in injurious numbers. The smaller yields were attributed to poor weevil control.

Lead arsenate was more effective against weevils than cryolite and more effective against the bollworms than calcium arsenate. When this poison was used for both weevil and bollworm control, particularly if the latter were injurious, yields were higher than when either of the other materials was used exclusively.

In 1942, basic copper arsenate proved to be the most effective against bollworms of any of the insecticides included in the experiments. The high yields resulting from the use of this insecticide appeared to be partially due to the presence of copper.

The two treatments resulting in highest gains were basic copper arsenate and alternate applications of calcium arsenate with lead arsenate in a schedule of applications for weevil and bollworm control.

1944 - Ivy, E. E. Tests with DDT on the more important cotton insects. J. Econ. Ent. 37(1):142.

A 2% DDT-pyrophyllite dust was comparatively ineffective against Alabama agrillacea Hbn. (35.5% kill) and Anthonomus grandis Boh. (18.5% kill) when applied at the rate of 32 lbs. per acre and had little effect on Aphis gossypii Glov. (15.4% mortality) in laboratory tests in which nicotine dusts (2%) gave 81% mortality.

1944 - Smith, G. L. Tests with DDT against the boll weevil. J. Econ. Ent. 37(1):144.

Pyrophyllite dusts containing 1% and 2% DDT, applied to caged cotton plants infested with adults of Anthonomus grandis Boh. during July and August, both gave 16% net mortality after 96 hours, as compared with 77% when calcium arsenate was used.

1945 - Bondy, F. F., and C. F. Rainwater. Cotton insects investigations. S.C. Agr. Expt. Sta. 1943-1944 Rpt. 57:99-104. Clemson.

Basic copper arsenate was as effective as calcium arsenate against the weevil. Lead arsenate, magnesium arsenate, potassium fluosilicate, barium fluosilicate, and synthetic cryolite were less so.

1945 - Gaines, R. C. Effect of reduced amounts of calcium arsenate on boll weevil control and cotton yield. J. Econ. Ent. 38(3):300-304.

In field-plot experiments conducted at Tallulah, La., from 1933 to 1943, the amount of calcium arsenate applied, either alone or in a mixture, was greatly reduced from the average application of about 6 lbs. per acre. Dosage significantly affected percentage of boll weevil control, but the effect on yield was not significant. Reductions in the amounts of calcium arsenate applied in cage tests were followed by reductions in the mortalities of boll weevils.

1946 - Annand, P. N. Report of the Chief of the Bureau of Entomology and Plant Quarantine, Agr. Res. Admin., U. S. D. A. 1944-45. Wash.

DDT was much less effective than calcium arsenate against the boll weevil in Louisiana in 1945. BHC had both fumigant and contact action against A. grandis and was more effective than DDT, although calcium arsenate gave the highest mortality.

1946 - Bishopp, F. C. The insecticide situation. J. Econ. Ent. 39(4):452.

A 10% dust of 2-hydroxy-2,4,4,4 prime, 7-pentamethyl flavan was ineffective against the boll weevil on cotton, much less effective than calcium arsenate.

1946 - Bondy, F. F. and C. F. Rainwater. Cotton insect investigations. S.C. Agr. Expt. Sta. 1944-1945 Rpt. 58:101-105. Clemson.

Field experiments over several years on the control of boll weevil on cotton in South Carolina showed that mopping at the presquare stage with a mixture of calcium arsenate molasses and water (1:1:1) reduced early weevil populations and effected some degree of control, but, as the time for mopping is usually over before the hibernating weevils have completed their emergence, this method was not satisfactory in years of heavy weevil damage.

Temperature was the most important factor determining the survival of A. grandis in winter, but humidity had the greatest influence on emergence in the spring. Emergence was late in dry springs, regardless of temperature, and early wet springs seemed to extend the period of emergence, although the larger percentage of weevils emerged early.

1946 - Isely, D. The cotton aphid. Ark. Agr. Expt. Sta. B. 462, p. 29, 3 illus.

The possibility of the development of an aphid outbreak, after calcium arsenate dusting for the cotton boll weevil, increases with the number of dust applications. Outbreaks also develop more rapidly where dusting is general in a region. Where spot dusting is practiced only for boll weevil control, the likelihood of aphid injury is relatively small.

1946 - Ivy, E. E., and K. P. Ewing. Benzene hexachloride to control cotton insects. J. Econ. Ent. 39(1):38-41.

In laboratory and cage tests at Waco, Tex., benzene hexachloride dust produced excellent control of several of the more important cotton insects. Control of the boll weevil and the cotton leafworm was better than with calcium arsenate.

1946 - Parencia, C. R., Jr., E. E. Ivy, and K. P. Ewing. Control of bollworm and cotton flea hopper by DDT. J. Econ. Ent. 39(3):329-335.

Infestation records made in various field-plot experiments showed that DDT does not give satisfactory control of the boll weevil. In one experiment 6 applications of DDT caused marked increases in populations of the red spider, Tetranychus sp.

A large-scale experiment conducted at Waco for maximum combination control of bollworm and boll weevil, using DDT-sulfur mixture and calcium arsenate produced an average of 1963 lbs. of seed cotton per acre on 36 treated acres and an average of 844 lbs. per acre on 2 adjoining untreated acres, or a gain of 1,119 lbs. per acre.

1947 - Becnel, I. J., H. S. Mayeux, and J. S. Roussel. Insecticide tests for the control of cotton boll weevil and cotton aphids in 1946. J. Econ. Ent. 40(4):508-513.

The results of one experiment indicated that 2.88% gamma benzene hexachloride controlled the boll weevil as effectively as did calcium arsenate or calcium arsenate-1% nicotine. However, results of another experiment indicated that to compare favorably with calcium arsenate for boll weevil control, it was necessary to use 5.17% gamma benzene hexachloride. Applications of mixtures containing calcium arsenate and benzene hexachloride resulted in large increases of aphids. The compatibility of these two materials was questioned.

Bollworms and red spiders increased following applications of benzene hexachloride, particularly following applications of 5.17% gamma isomer benzene hexachloride. The use of conditioned dusting sulfur as a diluent for benzene hexachloride prevented increased red spider infestations.

Calcium arsenate plus 1% nicotine produced higher yields of seed cotton than benzene hexachloride containing gamma isomer ranging from 1.44% to 2.88%. It was necessary to apply DDT to control bollworm in BHC-treated plots.

1947 - Brett, Charles H., and W. C. Rhoades. Boll weevil control with chlordane, benzene hexachloride, and calcium arsenate dusts. J. Econ. Ent. 40(4):572-574.

Field tests at Eufaula, Okla., during the season of 1946 showed talc dust containing 10%, by weight, chlordane applied at the rate of 10 lbs. per acre to be about as effective as calcium arsenate applied at the rate of 6 lbs. per acre in controlling the boll weevil. Benzene hexachloride dust containing 5%, by weight, gamma isomer applied at the rate of 10 lbs. per acre was somewhat more effective than the chlordane or calcium arsenate dusts.

Effectiveness of the control with insecticides decreased as an overlapping of weevil generations resulted in a daily reestablishment or increase of the population. Final yields showed about the same gain in a field where calcium arsenate was applied 1 week after appearance of the first squares and each week thereafter for a total of 3 applications as in a field where 5 dustings were made throughout the season with each application delayed until after 25% or more of the squares had become infested, despite the fact that the latter field had the lowest infestations.

Laboratory experiments demonstrated that susceptibility of the boll weevil to benzene hexachloride increased as temperature was increased. This was true to a lesser extent for chlordane. Dust containing 4% gamma isomer was more toxic than dust containing 4% chlordane concentrate.

1947 - Ewing, K. P., C. R. Parencia, Jr., and E. E. Ivy. Cotton-insect control with benzene hexachloride, alone or in mixture with DDT. J. Econ. Ent. 40(3):374-381.

In field-plot experiments at Waco, Tex., during 1946 benzene hexachloride dust containing at least 5% of the gamma isomer satisfactorily controlled the boll weevil, Anthonomus grandis Boh., the cotton aphid, Aphis gossypii Glov., and the cotton leafworm, Alabama argillacea (Hbn.), but produced no control of the bollworm, Heliothis armigera (Hbn.). Mixtures of 5% DDT and benzene hexachloride containing from 2.88 to 4.31% of the gamma isomer were effective in controlling the boll weevil. These mixtures in several late-season experiments adequately controlled heavy infestations of the boll weevil.

In one small-plot experiment a mixture of 5% DDT and benzene hexachloride, containing 4.31% of the gamma isomer, produced 1284 lbs. of seed cotton per acre, as compared with 678 lbs. from 5% DDT alone and 144 lbs. from the untreated check. In a large-scale experiment, begun when the bollworm infestation first developed, a plot treated with a mixture of 5% DDT and benzene hexachloride containing 2.88% of the gamma isomer produced a gain, over the check, of 1114 lbs. The gain from the mixture was almost twice as much as from calcium arsenate at approximately 16 lbs. per acre, and calcium arsenate at 16 lbs. produced a gain of more than twice as much as calcium arsenate at 8 lbs.

In field and cage tests benzene hexachloride gave a much quicker kill of the boll weevil than did calcium arsenate, but it lost most of its toxicity within about 2 days. On the other hand, against cotton leafworms its effect was much more residual than was that of calcium arsenate. There was evidence that benzene hexachloride may be incompatible with standard calcium arsenate.

1947 - Gaines, J. C. Comparison of insecticides for cotton insect control and the effect of copper on yields. J. Econ. Ent. 40(3):434-436.

Lead arsenate proved to be almost as effective as calcium arsenate when used against heavy infestations of weevils and was more effective against the bollworm. The benzene hexachloride-inert mixture containing 5.75% gamma isomer was effective against the weevil and prevented aphid increases, but permitted increased bollworm injury.

1947 - Gaines, J. C., and H. A. Dean. New insecticides for boll weevil, bollworm, and aphid control. J. Econ. Ent. 40(3):365-370.

Benzene hexachloride mixtures applied at the rate of 11 to 12 lbs. per acre, containing as low as 2.88% gamma isomer proved to be as effective against the weevil as calcium arsenate in one experiment, while in other experiments this percentage gamma isomer was less effective. The mixtures applied at from 11 to 12 lbs. per acre, containing at least 5% gamma isomer were equal to or, in one experiment, significantly more effective against weevils than calcium arsenate. Apparently a minimum dosage of 8 ounces of gamma isomer per acre was necessary to give adequate control of severe weevil infestations. Benzene hexachloride, in all concentrations used, prevented aphid increases, but produced increased bollworm injury. Five percent DDT dust mixtures were effective against the bollworm, but ineffective against bollils and caused aphid increases. Populations of red spiders were noted on both DDT and benzene hexachloride treated plots when sulphur was not used as a diluent. The mixture of DDT and benzene hexachloride was effective against weevils, bollworms and aphids, but did not significantly increase the yields over calcium arsenate.

1947 - Gaines, R. C., A. L. Scales, M. T. Young, and G. L. Garrison. Effect of benzene hexachloride mixtures upon four cotton insects and upon cotton yields at Tallulah, Louisiana, in 1946. Assoc. South. Agr. Workers Proc. 44:125.

Results obtained in laboratory tests, cage experiments, and field plot experiments indicated that benzene hexachloride was toxic to the boll weevil. One-half pound of gamma isomer in benzene hexachloride mixtures may be required.

1947 - Gaines, R. C., M. T. Young, and G. L. Smith. Calcium arsenate and nicotine to control boll weevil and cotton aphid, 1939-1946. J. Econ. Ent. 40(4):600-603.

In experiments at Tallulah, La., 2% of nicotine in alternate applications of calcium arsenate, 1% of nicotine in all applications of calcium arsenate, and calcium arsenate plus separate applications of a 3% nicotine dust as needed were equally effective for control of the boll weevil, and the cotton aphid, _Aphis gossypii_ Glov.

Early-morning and late-afternoon applications of nicotine-calcium arsenate mixtures, each, gave a significant increase in yield over calcium arsenate and over the checks. The late applications were slightly more effective.

1947 - Ivy, E. E., and K. P. Ewing. Laboratory and cage tests with newer insecticides to control cotton insects. J. Econ. Ent. 40(4):568-569.

Laboratory and cage tests designed to determine the effectiveness of several of the newer insecticides against cotton insects were conducted at Waco, Tex., during 1946.

Dust mixtures of chlordane were made by impregnating a dust with an acetone solution. Pyrophyllite was used in the 1% to 5% mixtures, and "fossil flour" (infusorial earth), in the 10% to 20% mixtures. At 10% and 20% concentrations chlordane was effective against cotton aphids and boll weevils, but not quite so effective as corresponding concentrations of chlorinated camphene or benzene hexachloride (gamma isomer 5.75%).

Sabadilla dusts had practically no effect on cotton aphids, cotton leafworms, bollworms, and boll weevils. Undiluted Ryania at 32 lbs. per acre was only moderately effective against boll weevils. Five percent hexaethyl tetraphosphate dusts were ineffective against boll weevils. A 25% azobenzene dust was nontoxic or only slightly toxic to boll weevils. Two dust compositions, one containing 0.5% of "piperonyl cyclohexenone" and 0.04% of pyrethrins in an unknown carrier, and the other containing 0.0125% of piperonyl butoxide and 0.001% of pyrethrins in pyrophyllite were not effective against boll weevils.

1947 - Ivy, E. E., C. R. Parencia, Jr., and K. P. Ewing. A chlorinated camphene for control of cotton insects. J. Econ. Ent. 40(4):513-517.

In cage tests, a dust containing 20% of chlorinated camphene, applied at the rate of 8 lbs. per acre, controlled the boll weevil, as well as did calcium arsenate or benzene hexachloride.

In field-plot experiments a dust containing 20% of chlorinated camphene gave adequate control of comparatively heavy infestation of bollworms, boll weevils, cotton aphids, and leafworms. The chlorinated camphene controlled the boll weevil about as well as calcium arsenate and was slightly superior to calcium arsenate in controlling the bollworm.

A mixture of 5% of DDT and benzene hexachloride containing 2.88 or 4.5% of the gamma isomer appeared to be slightly superior to chlorinated camphene against the bollworm, but about equal against the boll weevil, aphid, and leafworm. In a small-plot experiment (latin-square design) the yields were significantly higher from the chlorinated camphene and from the DDT-benzene hexachloride mixture than from the calcium arsenate.

1947 - Kulash, Walter M. Benzene hexachloride and chlordane to control cotton boll weevil. J. Econ. Ent. 40(5):644-650.

Benzene hexachloride dust, 5% gamma isomer content, was used in 6 replicated plots for the control of the cotton boll weevil under field conditions in the vicinity of Raleigh, North Carolina. Each plot consisted of 4 rows of cotton, 900 feet long. Plots were treated 5 times in the period from July 12 to August 14, 1946. In the July 12 and July 27 treatments, 1% gamma benzene hexachloride dust was used, but it did not check the abundance of the second brood weevils emerging at that time. The 3 other dust applications were made with dust containing 5% of the gamma isomer, and these later applications reduced the infestation of weevils considerably.

In the field, the 5% dust did not seem to have any marked residual effect on weevils 3 or 4 days after application. The 5% dust, if used too heavily, burned foliage.

In the laboratory, nearly 3,000 weevils were tested with various concentrations of benzene hexachloride dust, as well as chlordane dusts and sprays, according to 2 different methods of testing. Benzene hexachloride dusts of 1%, 2%, 5%, and 10% gamma isomer content did not show any marked difference in the number of weevils killed at 24 to 72 hours after treatment when the weevils were merely exposed to the dust and did not come in contact with it. According to the second method of testing, weevils were allowed to come in contact with the test materials immediately after they had been applied to freshly cut sprigs of cotton foliage. Up to 8 hours after exposure this method produced a more rapid knock-down and mortality at all concentrations than did the first method of testing, in which the weevils did not come in contact with the test materials.

Tests with benzene hexachloride dusts exposed to room air for 3 days before the introduction of the weevils (according to the first methods of treatment) showed that there was a marked reduction in the effectiveness of the dust at all 4 concentrations used.

Chlordane in dust and spray form was also used according to the 2 different methods of testing. Liquid formulations of chlordane were apparently more toxic to boll weevils than were dust formulations of the same material but the former did not produce as rapid a mortality as did the dusts.

Benzene hexachloride dusts, 2% and 5% gamma isomer content, were more toxic to boll weevils than chlordane dusts of 2% and 5% concentrations.

1947 - Rainwater, C. F. Some insecticides causing boll weevil mortality inside of punctured cotton squares. J. Econ. Ent. 40(6):923-925.

To test the ovicidal or larvicidal action of certain new insects, fallen fruiting buds or squares in which eggs had been deposited were collected from field treated plots and held in cages until emergence of weevils was apparently complete and then examined for weevil mortality. Calcium arsenate, 50% DDT or 1% to 5% 0,0-diethyl 0-p-nitrophenyl thiophosphate caused little mortality of weevils developing within the punctured squares. A 20% chlorinated camphene caused some mortality, but a 10% material evidenced very little. BHC and a mixture of BHC and DDT from 2 different sources gave wide differences in mortality. BHC did, however, give appreciable mortality. Chlordane was the most effective material tested.

1947 - Rainwater, C. F., and F. F. Bondy. New insecticides to control boll weevil and cotton aphid. J. Econ. Ent. 40(3):371-373.

Field experiments were conducted at Florence, S.C., to compare the effect of several insecticides and combinations of insecticides, including benzene hexachloride and DDT, against the boll weevil and the cotton aphid. For boll weevil control, benzene hexachloride at strengths of 1.0% to 5.75% of the gamma isomer compared favorably with calcium arsenate. Mixtures of DDT and benzene hexachloride were more promising than benzene hexachloride alone. Ryania powder (50%) did not compare favorably with calcium arsenate, benzene hexachloride, or DDT.

1948 - Dunnam, E. W., and S. L. Calhoun. Benzene hexachloride to control boll weevil and cotton aphid. J. Econ. Ent. 41(1):22-25.

Tests were conducted in the area of Stoneville, Miss., to compare benzene hexachloride with calcium arsenate and nicotine for the control of the boll weevil and the cotton aphid, Aphis gossypii Glov., respectively.

Benzene hexachloride at 5% concentration of the gamma isomer was as effective as calcium arsenate for boll weevil control when applied at the same rate per acre at 4- or 5-day intervals. The residual effect of benzene hexachloride in control of the boll weevil was at least no better than that of calcium arsenate, and a 7-day interval was beyond the range of effectiveness.

1948 - Ewing, K. P., and C. R. Parencia, Jr. Control of boll weevil and cotton aphid with dusts containing chlorinated camphene, benzene hexachloride or other new insecticides. J. Econ. Ent. 41(4):558-563.

Several experiments were conducted in Texas in 1947 to determine the value of some of the newer insecticides against the boll weevil and the cotton aphid, Aphis gossypii Glov. In a small-plot experiment at Wharton the yields of cotton dusted with calcium arsenate, 2 mixtures of DDT and benzene hexachloride, and 2 concentrations of chlorinated camphene showed no significant differences. However, the least weevil control and the lowest yield were obtained from the 10% chlorinated camphene plots.

In 5 large-scale experiments in the same general location, 20% chlorinated camphene gave slightly better control, and the 10% chlorinated camphene gave slightly poorer control than calcium arsenate. Aphids caused considerable damage in most of the plots dusted with calcium arsenate but not in those dusted with chlorinated camphene. As a result of the combined control of both weevils and aphids, both strengths of chlorinated camphene effected higher yields than the calcium arsenate. In experiments in which the dusted plots were strictly comparable, 20% chlorinated camphene produced a gain over the check of 539 lbs., as compared to a gain of 360 lbs. from calcium arsenate; and 10% chlorinated camphene, a gain of 494 lbs., as compared with 211 lbs. from calcium arsenate.

In a small-plot experiment at Waco, where both weevils and fleahoppers were causing damage, plots treated with calcium arsenate and 10% and 20% chlorinated camphene produced significantly more cotton than the check. The chlorinated camphene dusts were significantly better than the calcium arsenate. There was no significant difference in yield between the 2 concentrations of chlorinated camphene.

In another small-plot experiment at Waco, there was some indication that a special calcium arsenate was more compatible with benzene hexachloride, especially at 1% of the gamma isomer than was the regular calcium arsenate.

When parathion mixed with chlorinated camphene was dusted on cotton, the 2 insecticides appeared to be compatible, but indications were that 2% of parathion was not effective against the boll weevil.

1948 - Gaines, J. C., and H. A. Dean. Tests of insecticides for the control of several cotton insects. J. Econ. Ent. 41(4):548-554.

Twenty percent chlorinated camphene-sulphur and 3% gamma benzene hexachloride-5% DDT-sulphur gave significantly better control of the bollworm and higher yields than calcium arsenate. All 3 poisons were equally effective against the boll weevil. Of the 3, only calcium arsenate produced increased populations of aphids.

In a demonstration using 5-acre plots, the 3% gamma benzene hexachloride-5% DDT-sulphur gave better control of the bollworm than did calcium arsenate but no better control of the weevil. This mixture gave better control of the boll weevil than 20% chlorinated camphene-sulphur. The highest yield was produced on the plot treated with benzene hexachloride-DDT-sulphur mixture.

The 20% chlorinated camphene-sulphur and 3% gamma benzene hexachloride-5% DDT-sulphur were more effective against the bollworm than calcium arsenate. Calcium arsenate was as effective as these organic sulphur mixtures when used against the boll weevil.

In 2 experiments, these 2 organic sulphur mixtures produced more cotton than did calcium arsenate, while in another the calcium arsenate produced as much as the organics. Aphid increases did not result from the use of organic-sulphur mixtures.

1948 - Gaines, R. C., and A. L. Scales. Effectiveness of insecticides on the boll weevil in cotton squares in 1947. J. Econ. Ent. 41(3):519.

To test the fumigating action of insecticides, squares collected on August 18, were exposed for 21 days in airtight lantern globes to the vapors of only chlordan, benzene hexachloride, chlorinated camphene, or parathion (0,0-diethyl 0-p-nitrophenyl triophosphate). Squares collected on August 20 were taken to the laboratory and placed in a dusting chamber where they were given a fairly heavy application. After treatment the squares were placed in lantern globes for 19 days. This was a combination contact and vapor, or fumigation, test.

The vapors from the chlordan killed all the developing boll weevils and those from the benzene hexachloride and the parathion killed most of them. The chlorinated camphene did not give off vapors which affected, to any extent, the development of the immature stages. In the tests in the dusting chamber the chlordan and benzene hexachloride killed all the developing boll weevils, whereas parathion and chlorinated camphene were less effective.

In the fumigation test, the boll weevils treated with chlordan reached the adult stage and died within the squares. In the combination contact and fumigation test, both larvae and adults were found dead. The benzene hexachloride killed a larger proportion of larvae than of adults.

Beginning on August 18, 4 heavy applications of 4 insecticides were made on plots consisting of 4 rows 100 feet long. At the strengths used, chlorinated camphene and parathion had no effect whatever upon the developing boll weevils in cotton squares; whereas chlordan caused high mortality, and benzene hexachloride cause some mortality of the developing weevils.

1948 - Gaines, J. C., and Read Wipprecht. Effect of dusting schedules on the yield of cotton during 1947. J. Econ. Ent. 41(3):410-412.

Two experiments were conducted to compare 3 schedules: (1) early dusting to control thrips, followed by complete fleahopper, boll weevil, and bollworm control; (2) dusting for standard cotton fleahopper, weevil, and bollworm control; and (3) late dusting for weevil and bollworm control. Early-season applications of 5% DDT-sulphur or 3% gamma BHC-5% DDT-sulphur failed to prevent thrip

increases, although the latter did reduce populations after each application. Apparently yields were reduced slightly in plots receiving these early applications at the time plants were in the 4 to 8 leaf stage. Calcium arsenate-sulphur and the BHC-DDT-sulphur controlled fleahoppers, the latter being more effective. Yields from late season control with 6 treatments of calcium arsenate or BHC-DDT-sulphur were practically equal to those on plots receiving from 2 to 5 additional dustings earlier in the season. The BHC-DDT-sulphur mixture was faster acting than the calcium arsenate. The results indicate that it is more profitable to dust cotton the last 3 weeks of July and August with a quick acting mixture.

1948 - Gaines, R. C., and M. T. Young. Benzene hexachloride mixtures to control four cotton insects. J. Econ. Ent. 41(1):19-22.

Satisfactory control of the boll weevil was not obtained in this experiment. Only 2 treatments which caused a significant increase in yield over the check were with calcium arsenate and the 5.75% gamma benzene hexachloride.

In laboratory tests, vapors given off by benzene hexachloride killed boll weevils. Red spiders were more numerous on cotton which had been dusted several times with benzene hexachloride than on cotton dusted with other insecticides or an untreated cotton. Benzene hexachloride, when applied to cotton, killed many beneficial insects.

The results of these experiments indicate that benzene hexachloride should not be mixed with regular calcium arsenate.

1948 - Kulash, Walter M. New insecticides for cotton insect control. J. Econ. Ent. 41(6):986-987.

Field tests for control of cotton boll weevil and bollworm were conducted in small replicated plots in a field near Raleigh, N.C. Dust treatments were made with (1) 20 percent chlorinated camphene, (2) a combination dust of 3% gamma benzene hexachloride and 5% chlordan. Untreated checks consisted of (1) randomized check plots located in randomized blocks of the treatment area, (2) a center strip of check plots dividing the treatment area into 2 pairs of randomized blocks.

Five dust applications were made from July 22 to August 29. Each application received 10 pounds of dust per acre applied with a rotarytype hand gun. Lowest average weevil infestation at the end of the season was recorded for the 5% gamma benzene hexachloride treatment. The highest yield, based on total picking of seed cotton in 2 center rows of plots 10 rows wide by 75 feet long, was recorded in the 20% chlorinated camphene treatment.

1948 - Loden, Harold D., and Horace O. Lund. Chlorinated camphene and parathion to control the cotton boll weevil and cotton aphid. J. Econ. Ent. 41(6):851-853.

Chlorinated camphene and parathion dusts were tested against the cotton boll weevil and the cotton aphid in small-plot field experiments. Chlorinated camphene appears to maintain a residual killing power for the boll weevil for over 3 weeks, but neither chlorinated camphene nor parathion appears to exert any significant residual killing power against cotton aphids after 1 week. Regular weekly applications of calcium arsenate and chlorinated camphene appear to be about equal in their final effect upon the boll weevil populations, but the chlorinated camphene effects the control more rapidly. Parathion in the 1% concentration is not effective against the boll weevil. Yields of the plots treated weekly for 6 weeks with chlorinated camphene were statistically superior to all others except the calcium arsenate plots, but the calcium arsenate plots were not significantly superior to any others.

1948 - Scales, A. L., and G. L. Smith. Cage tests against the boll weevil and the tarnished plant bug with synthetic organic insecticides and calcium arsenate in 1947. J. Econ. Ent. 41(3):403.

Against the boll weevil, with the exception of 5% DDT, all the organic insecticides, parathion (0.5%-2%), chlordan (5%-20%), toxaphene (5%-20%), and BHC (1.25%-5% gamma), and mixtures of these insecticides were equal in effectiveness to calcium arsenate. Against the boll weevil, 20% of chlordan, a mixture of 10% of chlordan and 5% of DDT, and calcium arsenate gave the highest net mortalities, and all were equally effective.

1948 - Watts, J. Gordon. Cotton insect control with organic insecticides. J. Econ. Ent. 41(4):543-547.

In replicated plots and large-scale field tests, a dust mixture containing 5% DDT and 3% gamma isomer was the most effective of 5 insecticide formulations in increasing cotton yields. A 4.8% gamma isomer dust gave equal boll weevil control, although yields were slightly, though not significantly, less. A 20% chlorinated camphene ranked third in increasing cotton yields, but it was not significantly better than calcium arsenate containing 1% nicotine. A proprietary boll weevil spray which has been widely publicized and distributed failed to significantly increase cotton yields over the untreated check.

In preliminary tests on Grady sandy loam, a moderately heavy soil, 50% DDT and 36% chlorinated camphene, applied to the soil at rates as high as 200 lbs. per acre at the time of seeding, caused no apparent injurious effects to any of 19 crops. Similarly applied, 6% gamma isomer at 200 lbs. per acre caused light to severe reduction in stands of all crops. At 100 lbs. per acre none of the crops showed any apparent injury. It is significant that at all rates some of the plants survived and appeared to mature in a normal manner.

1948 - Young, M. T. Control of boll weevil and cotton aphid with benzene hexachloride and chlorinated camphene in 1947. J. Econ. Ent. 41(3):401-403.

Treatments with (1) benzene hexachloride, (2) chlorinated camphene, (3) alternate applications of a nicotine-calcium arsenate mixture and calcium arsenate, and (4) calcium arsenate alone were all equally effective against the boll weevil and the cotton aphid, whether applied early in the morning or late in the afternoon.

Three benzene hexachloride dusts, 5.0%, 2.5% and 1.25% gamma isomer, were more effective against both the boll weevil and the cotton aphid and caused a greater increase in yield when applied at 4- or 5-day intervals than when applied at 7- to 9-day intervals. Benzene hexachloride dusts containing 5% and 2.5% of the gamma isomer gave boll weevil control equal to that of calcium arsenate or alternate applications of the calcium arsenate-nicotine mixture and calcium arsenate, but yields were less.

Dusts containing 20% and 10% of chlorinated camphene were more effective against the boll weevil and the cotton aphid and yielded better when applied at 4- or 5-day intervals than when applied at 7- to 9-day intervals. However, neither the boll weevil control nor the yields from any of the chlorinated camphene dusts were as good as those from either calcium arsenate or alternate applications of the calcium arsenate-nicotine mixture and calcium arsenate.

Five applications of calcium arsenate plus 1 application of benzene hexachloride (5% of gamma isomer) gave better boll weevil control and a greater yield than alternate applications of the calcium arsenate-nicotine mixture and calcium arsenate. Benzene hexachloride mixture containing 5% of the gamma isomer, when used as a separate application with calcium arsenate in the boll weevil control program, gave better aphid control than 20% chlorinated camphene used in a similar way in the calcium arsenate program. Both benzene hexachloride and the chlorinated camphene permitted an increase of two-spotted spider mites.

1949 - Fife, L. C., R. L. Walker, Jr., and Floyd F. Bondy. Boll weevil control with several organic insecticides during 1948. J. Econ. Ent. 42(4):682-684.

Dusts containing 2% and 3% of the gamma isomer of benzene hexachloride plus 5% of DDT gave the best boll weevil control and the highest yields. A mixture containing 1% of the gamma isomer plus 5% or 10% DDT was not strong enough to give good weevil control. Toxaphene and chlordan at 10% strength plus 5% of DDT were about equal in controlling the boll weevil and increasing the yield, but they were less effective than a benzene hexachloride dust containing either 2% or 3% of the gamma isomer. Twenty percent of chlordan gave better boll weevil control and a higher yield than did 10%. The addition of 5% of DDT to 10% of chlordan did not increase the boll weevil control, but it increased the yield, probably owing to additional control of other injurious insects. Moreover, the addition of 1% of parathion or 1% of rotenone to the latter mixture gave

slightly higher yields. Boll weevil control was also obtained with a dust containing 3% of the gamma isomer of benzene hexachloride plus 5% of DDT plus 0.5% of parathion followed closely by 20% of toxaphene plus 0.5% of parathion and by a dust containing 2% of the gamma isomer plus 10% of DDT plus 40% of sulfur plus 2.3% of an unknown solvent.

These treatments also gave the highest yields. A moderate to light infestation of the red spider, Tetranychus atlanticus McG., developed after all treatments with the exception of the one containing 40 percent of sulfur. Higher yields and better boll weevil control were obtained at 3- and 5-day intervals of application than at the 7-day interval.

1949 - Gaines, J. C., and H. A. Dean. Effect of temperature and humidity on the toxicity of certain insecticides. J. Econ. Ent. 42(3):429-433.

In cage tests with boll weevils, the toxicity of calcium arsenate remained more nearly the same under all temperatures than did that of any of the organic insecticides used. However, the toxicity of this material was reduced, both by high temperature and high humidity. Laboratory-reared weevils were considerably more susceptible to the organic insecticides than were field-collected weevils.

High temperature and high humidity had less effect on the toxicity of 20 percent toxaphene than on that of the other organics. However, the toxicity of this material was reduced appreciably by high temperatures. The toxicity of 3 percent gamma benzene hexachloride-5 percent DDT was also reduced by high temperatures, necessitating dosages as great as 30 pounds per acre in order to obtain a high mortality.

The toxicity of 10 percent chlordane was greatly reduced by high temperatures. At the higher temperatures it was necessary to use 23 pounds of this material per acre in order to effect even a 50 percent mortality. In tests in which the weevils were released 24 hours after the plants were dusted, the toxicity of chlordane was further reduced.

In tests conducted at a constant temperature, high humidity reduced the toxicity of calcium arsenate, 20 percent toxaphene, and 20 percent chlordane.

A delay in releasing weevils 24 hours after dusting the plants, and the exposure of the dusted plants to the sun for 4 hours, resulted in reduced toxicity of 20 percent toxaphene.

1949 - Gaines, J. C., and H. A. Dean. Insecticide tests for boll weevil control during 1948. J. Econ. Ent. 42(5):795-798.

"Special calcium arsenate (lime free) mixed with either parathion or benzene hexachloride, and 20 percent toxaphene-sulfur were equally effective against the boll weevil. These materials were more effective than either benzene hexachloride-DDT-sulfur or chlordane-DDT-sulfur under the conditions of a hot season and heavy migration."

1949 - Moreno, Ignacio. Cotton insect control with new organic insecticides in Mexico. J. Econ. Ent. 42(3):484-486.

The work reported in this paper and carried on as a demonstration of the effectiveness of new organic insecticides for the control of various cotton insect pests in late-planted cotton in the Laguna District of Mexico suggests the following points:

(a) Cotton insect pests can be effectively controlled by the proper use of adequate insecticides.
(b) Where no cotton could formerly be picked due to insect damage, yields can be considerably improved through the use of insecticides.
(c) Frequent applications of insecticides at intervals of about 7 days are of the utmost importance.
(d) Benzene hexachloride, up to 6 percent gamma isomer, did not prevent a buildup of pink bollworm infestation, for which DDT is necessary. A 2 percent gamma isomer concentration of benzene hexachloride controlled

the cotton aphid and will prevent the buildup of a light boll weevil infestation if applied in time and at frequent intervals. For a heavy boll weevil infestation it might be necessary to apply benzene hexachloride with a higher gamma isomer content.

(e) It has been definitely demonstrated that the planting of cotton late in the season in the Laguna District of Mexico is unprofitable for the farmer. Although insect pests can be controlled, the high populations at the time make it necessary to apply insecticides twice as many times as in a normally planted cotton field, thus increasing the cost. Besides, early frosts will always constitute a menace to the late planted cotton fields and might reduce the yields to such an extent that the final crop will not pay for the cost of insecticides nor even for the high costs of cotton cultivation in the Laguna District.

1949 - Roussel, J. S., and J. C. Gaines. Comparison of calcium arsenates alone and mixed with organic insecticides for cotton insect control. J. Econ. Ent. 42(3):551-552.

In cage tests, commercial calcium arsenate and a special calcium arsenate were equally effective in their toxicity to the boll weevil.

1949 - Walker, R. L., Jr., L. C. Fife, and Floyd F. Bondy. Comparative effectiveness of chlorinated hydrocarbons against the boll weevil. J. Econ. Ent. 42(4):685-686.

The results of these experiments show that 50 percent or more of the knockdown and kill by each of the insecticides was effected within the first 24 hours. At the end of 2 and 6 hours, the benzene hexachloride mixture had caused a significantly greater knockdown and kill of weevils than had any of the other insecticides. After 144 and 168 hours, toxaphene had killed or paralyzed more weevils than the benzene hexachloride mixture, the difference closely approaching significance. There was no major difference between these two insecticides at any of the other counts. Both knocked down more weevils than any of the other materials tested, except at the 2-hour count.

Methoxychlor killed or paralyzed fewer weevils at each interval of the entire 7-day period than did any of the other treatments. No mortality occurred in the untreated check plots.

No rain fell during either of the tests. The mean temperature was 77°F. for the period of the first test and 79°F. for the period of the second test.

1950 - Bondy, Floyd F., L. C. Fife, R. L. Walker, Jr., and C. E. Jernigan. Profit in boll weevil control. S.C. Agr. Expt. Sta. Rpt. 2:68-70. Clemson.

To determine the net profit from poisoning for boll weevil control, records were made in 15 poisoned fields and 15 untreated fields in 1949. Five to 8 applications were made. Either a dust containing sufficient benzene hexachloride to give 4% of the gamma isomer plus 5% of DDT, or a 20% toxaphene dust, was used. The yield in the treated fields averaged 1,385 pounds of seed cotton per acre, as compared with 493 pounds in the untreated fields, or a gain of 892 pounds.

There was a net profit of $44.25 per acre due to poisoning for boll weevil control. The weevil-punctured squares in the poisoned fields averaged 18%, as compared with 73% in the nonpoisoned fields. Thirty-one more bolls were required to make a pound of seed cotton from the nonpoisoned fields than from poisoned fields. Two hundred open bolls from the poisoned fields weighed 2.55 pounds, as compared with 1.88 pounds for the same number of bolls from the nonpoisoned fields.

1950 - Bondy, Floyd F., L. C. Fife, R. L. Walker, Jr., and C. E. Jernigan. Spray or dust. S.C. Agr. Expt. Sta. Rpt. 2:70-71. Dec. Clemson.

During the past year many farmers, ginners, and manufacturers have asked for a comparison of sprays and dusts for boll weevil control. Sprayed and dusted plots were adjacent to each other in about 1-acre test areas in several fields at the Pee Dee station during 1949. Spraying gave control of boll weevils equal to or better than dusting; yields were about the same by both methods. Spray materials

for control of cotton insects have been available to farmers for about one year. At the present time the cost of spraying, as compared with dusting, is about the same. Spraying should be done from about 9 a.m. to 7 p.m., when the wind velocity is not more than 10 to 15 miles per hour.

Dusting should be done at night between 7 p.m. and 8 a.m. Usually the wind currents are too strong during the day to permit effective control for dusting.

1950 - Bondy, Floyd F., L. C. Fife, R. L. Walker, Jr., and C. E. Jernigan. Promising new organic insecticides. S.C. Agr. Expt. Sta. Rpt. 62:71. Dec. Clemson.

Three new insecticides were tested during 1949: aldrin, dieldrin, and heptachlor. All these poisons gave good boll weevil control when used as dusts at 10 pounds per acre, with application at the following strengths: aldrin, 2.5 percent; dieldrin, 1.5 percent; and heptachlor, 5 percent.

1950 - Bondy, Floyd F., L. C. Fife, R. L. Walker, Jr., and C. E. Jernigan. Best time to poison. S.C. Agr. Expt. Sta. Rpt. 62:71-72. Dec. Clemson.

Where only 3 poison applications were made, best results were obtained if dusting was begun at squaring time or 7 days after squaring and continued at 7-day intervals until completed. When 5 or more applications were made, best results were obtained by making 3 applications at 7-day intervals beginning at squaring and continuing with additional applications at 5-day intervals when the infestation reached 10% and for as long as it remained above 10% or until the crop was mature.

Three earlier applications beginning at squaring or 7 days after squaring gave higher increases in yield per application than 5 to 7 applications throughout the season. However, 5 or more applications for the entire season produced the highest yields and the most profitable gains.

1950 - Bondy, Floyd F., L. C. Fife, R. L. Walker, Jr., and C. E. Jernigan. Frequency of poison applications. S.C. Agr. Expt. Sta. Rpt. 62:72. Dec. Clemson.

To determine how often poison should be applied, 3 tests were conducted over a 2-year period. For midseason or late season poisoning these tests showed that after 5-day intervals of application, the average yield was 145 pounds of seed cotton per acre more than after 7-day intervals, regardless of the type of poison used.

If dusts are applied after blooming begins, they should be applied at 5-day intervals so long as the square infestation remains above 10% or until the crop is mature. However, if rain falls within 24 hours after dusting, the application should be repeated within 48 hours.

1950 - Calhoun, S. L., and W. R. Smith. Control of boll weevil, bollworm, and cotton aphid with organic insecticides applied as concentrated sprays. J. Econ. Ent. 43(5):606-610.

Several of the organic insecticides (chlorinated camphene, chlordane, DDT, BHC, and tetraethyl pyrophosphate), applied by airplane as concentrated sprays, at the same rate of toxicant per acre as recommended in dust form for boll weevil, bollworm, or cotton aphid control, gave moderate to excellent control of these insects in preliminary late season, large-scale tests at Belzoni and Rolling Fork, Miss.

The organic insecticides applied as sprays with ground equipment at Stoneville, Miss., failed to give any appreciable boll weevil control. Dilution of the insecticides, rain, extended intervals of application, and small plot size may have been factors contributing to the failure.

1950 - Dean, H. A., and J. C. Gaines. Comparison of dusts and sprays for cotton insect control. J. Econ. Ent. 43(2):225-226.

Under conditions of heavy boll weevil migration and moderate bollworm infestation, 3% gamma benzene hexachloride-5% DDT spray produced much poorer control of these insects and a significantly lower yield than toxaphene dust. The yield with toxaphene-DDT spray was significantly higher than toxaphene spray but equal to that of 20% toxaphene dust. All 3 sprays failed to control the boll weevil as well as did 20% toxaphene dust under this heavy weevil migration.

Toxaphene spray gave significantly less control of the boll weevil but as good control of the bollworm as special calcium arsenate-1% gamma benzene hexachloride under light infestations of weevil and moderate bollworm infestations. Ten percent chlordane-5% DDT, 3% gamma benzene hexachloride-5% DDT, and 20% toxaphene as dusts gave significantly better control of the bollworm than toxaphene spray or special calcium arsenate-1% gamma benzene hexachloride dust. Ten percent chlordane-5% DDT dust effected a significantly better yield of cotton than did toxaphene spray.

Toxaphene spray and toxaphene dust were equally effective against boll weevils and bollworms under light infestations of weevil and heavy bollworm infestations. Toxaphene-DDT spray gave better control of these insects than toxaphene spray or dust.

1950 - Dunnam, E. W., and S. L. Calhoun. Artificial defoliation of cotton and boll weevil control. J. Econ. Ent. 43(4):488-490.

Studies made at Stoneville, Miss., to determine the response of the adult boll weevil to the defoliating action of calcium cyanamide on cotton plants, and the value of this practice as a weevil control measure. Defoliation of cotton caused an almost immediate exodus of weevils to untreated fields. When cotton was treated as early as August 23, the boll weevil did not reach maturity in any second growth forms before frost on November 1. Removal of leaves, squares, and young bolls artificially checked plant growth, accelerated opening of bolls, and made an earlier harvest possible. Under these conditions cotton stalks can be destroyed earlier in the season, thereby offering a supplement to the regular campaign to destroy the cotton stalks as a boll weevil control measure, or a substitute for destroying stalks.

Defoliation is practiced extensively in the Mississippi Delta as an aid to mechanical harvesting, but it is also very beneficial for boll weevil control.

1950 - Fenton, F. A. Spraying and dusting for cotton insect control. J. Econ. Ent. 43(3):292-294.

Spraying cotton by plane or with a low-gallonage sprayer operated at from 60 to 80 psi, with an emulsion containing toxaphene and DDT, produced good control of boll weevils and bollworms. The average amount of toxaphene applied varied from 1.5 to 1.8 pounds per acre per application; DDT, 0.75 to 0.9 pounds. Comparative counts of infestations and yields showed that control was as good as was obtained with several dust formulations recommended for boll weevil control.

1950 - Fife, L. C., R. L. Walker, Jr., and C. E. Jernigan. Low-gallonage emulsion sprays gave effective boll weevil control. S.C. Agr. Expt. Sta. Rpt. 63:95-96. Dec. Clemson.

Extensive tests were conducted to compare low-gallonage emulsion sprays with dusts for control of the boll weevil. Sprayed and dusted plots of about 0.5 acre each were adjacent to each other, so that the results were directly comparable. All treatments were replicated in 3 fields.

All the plots were dusted or sprayed the same number of times and on the same dates. The number of applications ranged from 10 to 12 for the different fields, and applications were made at 5- to 7-day intervals, beginning when the first fruiting forms were noted.

Spraying or dusting gave equal control of the boll weevil. With the possible exception of plots treated with aldrin, in which dust proved better than the spray, yields from comparable plots were about the same for both methods. Excellent boll weevil control was obtained with all insecticides tested; the increase in yield averaged about 1,000 pounds of seed cotton per acre.

1950 - Fife, L. C., R. L. Walker, Jr., and C. E. Jernigan. Tobacco sprayers can be used for applying wettable-powder sprays for cotton insect control. S.C. Agr. Expt. Sta. Rpt. 63:97. Dec. Clemson.

Sprays made from wettable powders of toxaphene, chlordane, and BHC plus DDT were applied with the regular 2-row tobacco sprayer for boll weevil control.

Excellent control of boll weevils was obtained with all materials tested. The seasonal average of boll weevil-punctured squares was about 36% in the treated plots, as compared with 90% in the untreated check. Increases in yields ranging from 808 to 1,191 pounds of seed cotton per acre were obtained from all treatments.

1950 - Fife, L. C., R. L. Walker, Jr., and C. E. Jernigan. Several promising new pesticides tested. S.C. Agr. Expt. Sta. Rpt. 63:98-99. Dec. Clemson.

Compound 1189 and Dilan, where applied as a dust at the rate of 2 pounds of technical grade per acre, were less effective against the boll weevil than the recommended insecticides.

1950 - Fife, L. C., R. L. Walker, Jr., and C. E. Jernigan. Profit realized from boll weevil control. S.C. Agr. Expt. Sta. Rpt. 63:98. Dec. Clemson.

Tests were conducted in 6 fields with a total area of about 30 acres. Half of each field was dusted and half was sprayed. Two untreated outside plots of 1/2-acre, each, served as checks.

There was a net profit of about \$116 to \$119 per acre, and, for each dollar spent for poisoning, there was a return of about \$5.

In one field, which produced 1-1/4 bales per acre, the net profit was about \$175 to \$182 per acre for the dusted and sprayed plots, respectively, and for each dollar spent for poisoning there was a return of about \$8.

1950 - Gaines, J. C., and H. A. Dean. Effect of climatic factors on the toxicity of certain insecticides. J. Econ. Ent. 43(5):602-605.

The results of cage toxicity tests with boll weevils under the conditions of average daily temperatures ranging from 76^{o} to 91^{o}F. are shown. The toxicity of benzene hexachloride-DDT spray was greater than either benzene hexachloride-DDT dust, toxaphene spray or dust, or toxaphene-DDT spray at the 50 percent mortality level. The toxaphene spray was equally as toxic as the benzene hexachloride-DDT at the high levels of mortality.

The results of similar tests with boll weevils under the conditions of average daily temperatures ranging from 75^{o} to 103^{o}F. are shown. The toxicity of all materials was increased by the higher temperatures. There was little difference in the toxicity of toxaphene-DDT spray and toxaphene spray or dust at all levels of mortality. The benzene hexachloride-DDT spray was slightly more effective than the benzene hexachloride-DDT dust.

Exposing the treated plants to sunshine and simulated dews reduced the toxicity of all insecticides used. In general, the toxaphene and toxaphene-DDT sprays remained more toxic when exposed to simulated dews and sunshine than toxaphene dust or benzene hexachloride spray or dust.

1950 - Gaines, J. C., and Read Wipprecht. Evaluation of dusting and spraying schedules for cotton insect control. J. Econ. Ent. 43(3):286-288.

Under the conditions of these experiments, it is apparently more economical to apply insecticides for the control of injurious populations of insects (as needed) than to apply applications early in the season plus the necessary later applications to protect the crop from weevils and bollworms.

1950 - Hanna, R. L., and J. C. Gaines. Tests of insecticides for control of cotton insects during 1949. J. Econ. Ent. 43(3):288-289.

Three experiments indicated that the calcium arsenate mixtures used were slightly more effective against the boll weevil than were the organic insecticides used, while the organic insecticides were slightly more effective than the calcium arsenate mixtures against the bollworm. When yields were used as the criterion, all the materials were equally effective in controlling infestations of both boll weevil and bollworm.

Aldrin was not so effective against the bollworm and boll weevil as toxaphene-sulfur and calcium arsenate-parathion.

The organic insecticide mixtures produced higher yields than the special calcium arsenate mixture due to better bollworm control.

The addition of parathion or benzene hexachloride to the special calcium arsenate was effective in preventing aphid increases.

1950 - Isely, Dwight. Control of the boll weevil and the cotton aphid in Arkansas. Ark. Agr. Expt. Sta. B. 496. June. Fayetteville.

Outbreaks of aphids tend to follow outbreaks of weevils when insecticidal control is undertaken, especially with Ca arsenate. Controls with calcium arsenate, toxaphene, and 3-5-40 (BHC-DDT-sulfur) are discussed.

1950 - Ivy, E. E., and A. L. Scales. Dieldrin for cotton insect control. J. Econ. Ent. 43(5):591-592.

Tests were conducted in field cages and in the laboratory.

A dust containing 5% of dieldrin gave a higher kill of weevils, and one containing 2.5%, a slightly lower kill than the 20% toxaphene dust. Statistically, there was no significant difference in the effectiveness of these 3 formulations. However, a dust containing 1.25 percent of dieldrin gave a significantly lower kill.

Sprays were applied at the rate of 3 gallons per acre.

Dieldrin in both spray and dust formulations appears to be somewhat more resistant to removal by rain than does toxaphene.

After artificial showers, sprays or dusts at 0.25 and 0.5 pound of dieldrin per acre were more effective than toxaphene at 2 pounds per acre. The addition of either of 2 commercial stickers, applied at the rate of 0.5 pound per acre, did not increase the effectiveness of the 0.25 pound treatments on washed plants.

In laboratory tests conducted to determine the effectiveness of dieldrin against boll weevils developing inside of squares, dieldrin killed many of the developing forms.

1950 - Ivy, E. E., Wm. Iglinsky, Jr., and C. F. Rainwater. Translocation of octamethyl pyrophosphoramide by the cotton plant and toxicity of treated plants to cotton insects and a spider mite. J. Econ. Ent. 43(5):620-626.

Octamethyl pyrophosphoramide appeared to be highly specific for aphids and mites. It did not kill the boll weevil, either as adults or as larvae developing inside squares of treated plants.

1950 - Magee, W. J., and J. C. Gaines. Toxicity of Phosphorus Compounds to Various Insects. J. Econ. Ent. 43(3):282, 284-285.

Results of laboratory cage tests in which the toxicity of 7 new phosphorus compounds were compared with parathion show that in general these newer compounds were less toxic to most of the species of insects used. However, in a few cases the toxicity of several of the newer compounds was equal to the toxicity of parathion. It was noted that in some instances the higher dosages of the newer compounds resulted in reduced toxicity. This is believed to be due to some repellant action exerted by the insecticide at higher concentrations.

The newer phosphorus compounds proved to be less toxic than parathion to the boll weevil.

Materials 3869 and 3901 were not effective in the control of either boll weevils or bollworms under existing field conditions.

1950 - Mistric, Walter J., Jr., and C. F. Rainwater. Laboratory experiements to determine the insecticidal action of several organic insecticides against boll weevil. J. Econ. Ent. 43(6):892-898.

Laboratory experiments were conducted at College Station, Tex., during 1949 to determine the specific components of insecticidal activity of the following insecticides and the 4 principal isomers of benzene hexachloride against the boll weevil: (1) technical benzene hexachloride, (2) aldrin, (3) dieldrin, (4) toxaphene, (5) chlordane, (6) 1,1-bis (p-chlorophenyl) 2-nitropropane, (7) 1,1-bis (p-chlorophenyl) 2-nitrobutane, and (8) DDT. The components of insecticidal activity determined were direct fumigating action, indirect fumigating action resulting from plant fumigation, contact action, and combined action.

Direct fumigating action was demonstrated to a marked degree for benzene hexachloride, chlordane, aldrin, and dieldrin. Indirect fumigating action, that resulting wholly from plant fumigation, was demonstrated for all primary

insecticides tested, except CS-645A, and for the delta and alpha isomers of benzene hexachloride.

Significant contact action was demonstrated for aldrin, dieldrin, and benzene hexachloride. That for benzene hexachloride was largely attributable to the gamma isomer.

Toxaphene, chlordane, and compound CS-645A kill largely by stomach action. Stomach action contributes greatly to total effect from all 8 primary insecticides tested.

1950 - Parencia, C. R., Jr., and K. P. Ewing. Late-season control of boll weevil and bollworm with dusts and sprays. J. Econ. Ent. 43(5):593-595.

Insecticides applied as dusts and as low-volume sprays were tested in a single small-plot, and in several large-scale, field experiments at Waco, Texas, during 1949 against late-season infestations of the boll weevil and the bollworm, Heliothis armigera (Hbn.). A 2.5% dieldrin dust gave better results than a 20% toxaphene dust in the small-plot experiment conducted for control of the boll weevil. A dust containing 2.5% of aldrin, 5% of DDT, and 40% of sulfur gave results approximately equal to that of a 20% toxaphene dust in 2 experiments against the boll weevil. In each of 3 experiments records of square-infestation showed that 20% toxaphene dust gave better control of the boll weevil than did 10% or 7.5% chlordane mixed with 5% DDT. In the small-plot experiment the yield was higher, but not significantly, from the toxaphene than from the chlordane-DDT mixtures. Aphid, Aphis gossypii Glov. , infestations approaching the damage point developed after the applications of chlordane-DDT dust mixtures in 1 of the large-scale experiments. In 1 experiment aldrin-DDT applied as a spray gave better boll weevil control and higher increases in yield than toxaphene-DDT or chlordane-DDT applied as sprays. A toxaphene dust gave somewhat better boll weevil control than a toxaphene-DDT spray, but there was a slight difference in favor of the spray in control of the bollworm.

1950 - Parencia, C. R., Jr., and K. P. Ewing. Comparison of early-season, late-season, and a combination of early-season plus late-season insecticide applications for cotton insect control. J. Econ. Ent. 43(5):596-598.

Field-plot experiments were conducted in the Waco area during 1949 to compare early-season, late-season, and early- plus late-season insecticide applications for cotton insect control.

The cotton which received early-season treatment set and matured its crop 2 to 3 weeks earlier than cotton which received no early treatment. Control of thrips (several species), overwintered weevils, Anthonomus grandis Boh., and other early-season insects was approximately the same when a dust and a spray were compared. Plots receiving an average of 3.5 early-season applications produced a gain of 317 pounds of seed cotton per acre over plots receiving no treatment; plots receiving an average of 5 late-season applications produced a gain of 379 pounds; and plots receiving an average of 7.3 early plus late applications produced a gain of 460 pounds.

The results of these experiments indicate that early-season insecticide applications may be more economical than late-season applications in the Central Texas area, even though entire farms or communities are not treated.

Late-season applications, especially on highly productive land, are likely to be needed after early-season applications on areas smaller than entire farms or communities.

1950 - Scales, A. L., E. E. Ivy, and C. F. Rainwater. Preliminary evaluation of two nitroparaffin insecticides against four cotton insects. J. Econ. Ent. 43(4):560-561.

At the rates tested against the boll weevil, neither compound CS-645A nor CS-674A, corresponding to the chemicals [2-nitro-1,1-bis (p-chlorophenyl) propane] and [2-nitro-1, 1-bis (p-chlorophenyl) butane], respectively, compared favorably with 20 percent toxaphene.

1950 - Smith, W. R., and S. L. Calhoun. Comparative effectiveness of aldrin applied at different times of the day for boll weevil control. J. Econ. Ent. 43(5):598-601.

A large-scale field test was conducted near Stoneville, Miss., in which aldrin was applied 9 times from July 26 to September 3 as an emulsion spray by airplane for control of the boll weevil. Applications were made at 6 and 10 a.m. and at 2 and 6 p.m. to determine the influence of climatic factors occurring at different times of the day on toxicity of the insecticide.

Treatments made at 6 p.m. resulted in significantly better control than those made at 6 a.m. or 2 p.m. but were only slightly better than the one applied at 10 a.m. There was no significant difference in yield between the treated plots. All treatments held the infestation sufficiently low to prevent a reduction in yield. The treated plots yielded from 656 to 772 pounds more seed cotton per acre than the untreated check plot.

Wind movement, temperature, convection currents, and dew were suggested as factors contributing to the differences observed in boll weevil control.

1950 - Walker, R. L., Jr., L. C. Fife, and Floyd F. Bondy. Dusting-schedule experiments with Toxaphene for boll weevil control. J. Econ. Ent. 43(6):946-947.

This summary shows good increases in yield from 3 applications of a 20% toxaphene dust, regardless of the schedule used. The gains in pounds of seed cotton per acre per application of insecticide were almost identical for all the schedules when only 3 applications were made. Additional applications always resulted in greater increases in yield per acre, but the increases were not in proportion to those made from the first 3 applications. The data shows an increase in yield of approximately 135 pounds of seed cotton per acre for each of the first 3 applications, beginning at time of squaring, 1 week after squaring, or at 10% infestation. For applications in excess of the first 3, the average increase was approximately 50 pounds per acre.

During the 2 seasons of these tests, boll weevil emergence from hibernation was earlier than normal for this locality. Moreover, weather conditions caused cotton to mature earlier than normal. In years when the weevil emergence is delayed and cotton matures over a longer period, different results might be expected.

1950 - Young, M. T., and R. C. Gaines. Tests of insecticides to control boll weevil, cotton aphid and two-spotted mite. J. Econ. Ent. 43(5):727-729.

Experiment 1--A mixture of calcium arsenate plus 2% of nicotine alternated with calcium arsenate alone; a mixture containing sufficient benzene hexachloride to give 3% of the gamma isomer, DDT 5%, and sulfur 40%, when used alone or then alternated with various applications of calcium arsenate; and toxaphene 20% plus sulfur 40% gave good control of the boll weevil.

Experiment 2--Benzene hexachloride gamma 3% plus sulfur 40% gave good control of the boll weevil. This mixture was much more effective in increasing the yield when 5% of DDT was added. A mixture of calcium arsenate plus 2% of nicotine alternated with calcium arsenate, calcium arsenate alone, and a mixture of benzene hexachloride gamma 3% plus DDT 5% plus sulfur 40%, as needed, against cotton aphids gave good control of the 2 cotton insects and the mite, as well as very satisfactory gains in yield over the check. Chlordane 20% in clay applied at 1 pound per acre per application, and chlordane 10% in pyrophyllite applied at 1.1 pounds were equally effective against boll weevils. However, chlordane was much less effective than most of the other insecticides included in this experiment.

Experiment 3--A dust containing 2% of aldrin gave good control of the boll weevil and the cotton aphid, but not of the spider mite.

Experiment 4--The 2 brands, A and B, of special low-lime calcium arsenate and regular calcium arsenate were equally effective. The special calcium arsenates plus benzene hexachloride gamma 1% were much more effective in preventing an aphid buildup than a similar mixture with regular calcium arsenate.

1951 - Beckham, C. M., and M. Dupree. Progress report--summary of cotton insect control experiments during 1951. Ga. Expt. Sta. Mimeo. Series 38. Dec.

Includes a report on 3 experiments--(1) a comparison of the effectiveness of several commonly used insecticides applied as emulsifiable concentrates (toxaphene-DDT), (aldrin-DDT), and (dieldrin-DDT); (2) effectiveness of dust formulation (BHC-DDT), (aldrin-DDT), (heptachlor-DDT), (toxaphene), (dieldrin-DDT), and (calcium arsenate); (3) dust formulation comparisons. No conclusions were drawn by the author.

1951 - Gaines, J. C., H. A. Dean, and Read Wipprecht. Tests of insecticides for control of cotton insects during 1950. J. Econ. Ent. 44(3):367-372.

In a split-plot, randomized, block experiment, toxaphene, toxaphene-DDT, and gamma benzene hexachloride-DDT dusts proved equally effective for boll weevil and bollworm control. The spray formulation of toxaphene-DDT was as effective as the dusts. Toxaphene and gamma benzene hexachloride-DDT sprays were not so effective as the toxaphene-DDT spray nor the toxaphene dust. In laboratory tests, toxaphene-DDT spray proved more effective than toxaphene spray for control of the boll weevil, particularly at the high levels of kill. The mixing of toxaphene and DDT did not increase the toxicity of the mixture for control of the weevil over comparable dosages of toxaphene and DDT applied separately.

In large plots, results were obtained comparable to those of the small replicated plots. Results from the 4 tests with plots ranging in size from 1 to 40 acres indicate that sprays applied either with a tractor or an airplane were effective for boll weevil and bollworm control. In the tests, 6 to 12 applications were required, and average net gains in yields over the check plots ranged from 672 to 1,223 pounds of seed cotton per acre, a net profit ranging from $75 to $133 per acre.

1951 - Gaines, J. C., E. E. Ivy, and C. E. King. Toxicity of certain phosphorus compounds to cotton insects. J. Econ. Ent. 44(5):750-753.

The new phosphorus compounds TM-4049, S-(1,2-dicarbethoxyethyl) 0,0-dimethyl dithiophosphate; TM-4018, S-(1,2-dicarbomethoxethyl) 0,0-diethyl dithiophosphate; TM-4124, 0,0-dimethyl 0-2-chlor-4-nitrophenyl thio-phosphate proved less toxic than either tetraethyl pyrophosphate or parathion for spider mite control. TM-4124 was more toxic to mites at the 50% mortality level than either TM-4018 or TM-4049, while the compounds had about the same degree of effectiveness at the high levels of mortality.

In laboratory tests TM-4124 proved highly toxic to aphids, and in a field test compounds TM-4124 and TM-4049 applied at 0.3 and 0.4 pounds per acre, respectively, gave excellent control.

Neither of the phosphorus compounds tested proved so toxic to the bollworm as toxaphene. TM-4124 was effective against the boll weevil. A mixture containing 3% of TM-4124 and 15% of toxaphene proved effective against both boll weevils and bollworms.

1951 - Gaines, J. C., and W. J. Mistric, Jr. Effect of rainfall and other factors on the toxicity of certain insecticides. J. Econ. Ent. 44(4):580-585.

In laboratory and greenhouse tests, spray formulations of toxaphene, aldrin, and dieldrin proved to be more effective for boll weevil control than did the dust formulations. Considerably higher dosages of these insecticides applied as spray emulsions were necessary to give a kill in the field comparable to that in either the laboratory or greenhouse. Since the temperatures did not vary much in either location, it is assumed that the wider range in percentage relative humidity, sunshine, dew, and wind or a combination of these factors, brought about a decided reduction in the toxicity of toxaphene, dieldrin, and aldrin. These factors reduced the toxicity of aldrin more than either toxaphene or dieldrin.

The application of 0.5 inch of simulated rain did not affect the toxicity of toxaphene or dieldrin sprays when used to boll weevil control in the laboratory. The toxicity of aldrin spray was, however, greatly reduced by the simulated rain.

Considerably higher dosages of toxaphene, dieldrin, and aldrin were required for a kill of weevils in late September and October comparable to that obtained in August. It is assumed that certain factors other than environmental greatly affect the toxicity of these insecticides. These factors probably involve the physiology of the weevil, itself.

No differences were found in the toxicity of toxaphene sprays made from miscible oil concentrates containing 3 different emulsifiers in tests for boll weevil control. In tests for control of the salt-marsh caterpillar, there was a difference in the toxicity of the sprays made from oil concentrates containing these different emulsifiers. The toxicity of 2 of the emulsifiable sprays was reduced by the simulated rain in the experiment in which salt-marsh caterpillars were used as the test insects. Apparently the type of emulsifier used in making the miscible oil concentrate affects the toxicity of the spray emulsion as well as its residual toxicity following rains.

One-half inch of simulated rain greatly reduced the toxicity of toxaphene-sulfur dusts. The addition of either oil or a commercial sticker to toxaphene-sulfur dusts had little or no effect on the residual toxicity following simulated rain.

1951 - Hanna, R. L., and J. C. Gaines. Lime-free calcium arsenate mixed with organic insecticides for cotton insect control. J. Econ. Ent. 44(3):430-432.

Previous experiments at this station have indicated that lime-free calcium arsenate mixtures containing 1% gamma benzene hexachloride or 0.5% parathion were at least as effective as 20% toxaphene-40% sulfur or 3% gamma benzene hexachloride-5% DDT-40% sulfur for controlling the boll weevil and that 1% gamma benzene hexachloride or 0.5% parathion added to the calcium arsenate would prevent the buildup of aphids on the treated cotton.

Tests conducted during the 1950 season generally confirmed this previous work. One experiment demonstrated that calcium arsenate-1% gamma benzene hexachloride, calcium arsenate-0.5% parathion, and 20% toxaphene-40% sulfur were equally effective in controlling a severe infestation of boll weevils and a moderate infestation of bollworms. Calcium arsenate-0.5% parathion gave better control of boll weevils than 10% chlordane-5% DDT.

The results of 3 seasons' tests in the Brazos River bottoms near College Station, Texas, indicated: (1) that lime-free calcium arsenate plus 1% gamma benzene hexachloride or 0.5% parathion is at least as good as any insecticide in general use for controlling boll weevils; (2) that, except in extreme cases, the percentages of benzene hexachloride or parathion, as mentioned above, will prevent a buildup of aphids on cotton treated with these mixtures; (3) that the addition of as much as 2.5% DDT to these mixtures gives excellent bollworm control.

1951 - Isely, D., and G. Barnes. Boll weevil control in late summer. Ark. Agr. Expt. Sta. B. 510. May.

BHC, 3-5-40, and calcium arsenate were tested late in the summer of 1950. Although the number of punctures were never reduced below 30%, the data suggests that the greatest return from dusting will be gained if control measures are concentrated in periods during which cotton is fruiting most rapidly and if controls are continued as long as needed.

1951 - Lincoln, Charles. Boll weevil infestations and control in eastern Arkansas in 1950. J. Econ. Ent. 44(5):766-769.

Boll weevil infestations were extremely variable in eastern Arkansas early in the summer of 1950. During June and July early planted cotton was more heavily infested than later cotton. Infestations built up to high levels in August in all areas under consideration, including areas with extremely light early infestations. Despite heavier infestations by overwintered and first-generation weevils, control was easier in early cotton because it required a shorter period of protection from weevils of the second and later generations.

Application of insecticides early in the season did not reduce later infestations sufficiently to reduce the necessity of control measures later in the season.

Regular applications of insecticides were necessary to keep heavy infestations under control late in the season. Where they were so applied, control was excellent and migration was prevented almost completely.

Timing applications by presence of feeding punctures and live weevils held infestations at low levels without wasting insecticides.

1951 - Rainwater, C. F., and J. C. Gaines. Seasonal decline in the effectiveness of certain insecticides against boll weevil. J. Econ. Ent. 44(6):971-974.

Field cage tests conducted at College Station, Tex., over a 3-year period verify the observed fact that certain insecticides are less effective against the boll weevil late in the season than they are earlier. In general, toxaphene, benzene hexachloride, aldrin, and dieldrin were approximately 50% as effective in October as in July, whereas undiluted calcium arsenate was approximately 67% as effective. The period of greatest reduction in effectiveness occurred in September and October, as contrasted with the effectiveness of June and July.

Toxaphene was consistently less effective month by month from June to September, inclusive, for each of the 3 years. Increased concentrations and increased dosages up to 4 times the normal rate of application did not significantly affect the percent kill of late-season boll weevils. Additional tests showed that it required 240 times as much toxaphene to kill the same percentage of boll weevils in October as in July, and that all the other insecticides tested required extremely high dosages to effect kill in October comparable to that obtained in July.

In tests designed to determine comparative residual effectiveness, aldrin and benzene hexachloride lost considerably more than 50% of their effectiveness within 1 day, whereas heptachlor, dieldrin, and toxaphene lost 39%, 32%, and 45%, respectively. Calcium arsenate lost none of its effectiveness in 1 day, and EPN lost only 2%. After 5 days the chlorinated hydrocarbon insecticides were virtually ineffective.

1951 - Reed, John K., and M. D. Farrar. Bio-assay of cotton dusts with adult boll weevil. J. Econ. Ent. 44(6):1013-1014.

Appropriate averages from 420 samples of commercial dusts tested on boll weevils under laboratory conditions show (1) the use of sulfur as a diluent in cotton dusts added little or nothing to the kill of adult boll weevils; (2) 20% toxaphene dusts gave a higher rate of kill and killed faster than 3-5 benzene hexachloride-DDT in the laboratory.

A 3-5-0 benzene hexachloride-DDT dust mixed by grinding killed boll weevils quicker and required less dust for equal mortality than a similar dust in which the insecticide was impregnated on a carrier.

1951 - Smith, W. R., and S. L. Calhoun. Spraying for early-season control of boll weevil. J. Econ. Ent. 44(6):919-920.

Tests were conducted in 9 fields on 5 southern Mississippi Delta plantations in 1949 to determine the efficiency of toxaphene applied as a spray by tractor-mounted equipment for early-season control of the boll weevil. The cost of application and the feasibility of incorporating cotton insect control with regular cultivation were also investigated.

Sprays could be applied efficiently in the course of cultivation, and the application of toxaphene during the prebloom and early-bloom stages of cotton development delayed by 19 days the date when 25% of the squares became infested.

A significant difference in seed-cotton yield was observed in 6 of the 9 treated fields. Climatic conditions reduced the effectiveness of regular seasonal applications of poison, and poor control of the boll weevil was obtained in most fields.

1952 - Fife, L. C., Floyd F. Bondy, and R. L. Walker, Jr. Spray versus dust for boll weevil control with ground equipment. J. Econ. Ent. 45(1):16-19.

Spray and dust formulations of chlordane plus DDT, toxaphene plus DDT, benzene hexachloride plus DDT, toxaphene, dieldrin, and aldrin were tested in large field plots for boll weevil control during 1949, at Florence, South Carolina.

The dusts were applied at about 11 pounds per acre-application, and the sprays, at approximately 9 gallons.

The dusts and sprays were applied with 4-row horse-drawn equipment powered by 1.5-horsepower motors mounted on a platform about 42 inches above the ground. Approximately the same amount of active ingredients was applied per acre in both the dust and spray for each formulation tested.

Both the dusts and sprays of all formulations gave good boll weevil control and good increases in yield of seed cotton. Dieldrin, in both the dust and spray, was the most outstanding material tested.

Based on an average of 3 large field tests, the plots sprayed with chlordane plus DDT, toxaphene plus DDT, and toxaphene produced slightly higher yields than the dusted plots. With benzene hexachloride plus DDT, however, the dusted plots outyielded the sprayed plots.

For boll weevil control there was no advantage in adding DDT to toxaphene, either as a dust or as a spray.

None of the various dust or spray formulations used in these experiments caused any commercial injury to the cotton plant.

From the standpoint of boll weevil control, cost of materials and equipment, and the possibility of making spray applications in conjunction with tractor cultivation, low-gallonage spraying shows excellent promise.

1952 - Gaines, J. C., and W. J. Mistric, Jr. Effect of environmental factors on the toxicity of certain insecticides. J. Econ. Ent. 45(3):409-416.

Results of field cage tests indicated that overwintered weevils were more susceptible to toxaphene spray than weevils reared from squares during the early fruiting season. Apparently the depletion of food in the overwintered weevil affected their susceptibility to toxaphene.

Also, about 4 times as much toxaphene was required to kill weevils reared from bolls as from squares. These data indicated that the type of food upon which the weevils develop affects their susceptibility to toxaphene.

The results of all the weevil tests indicate that it required 4 or more times as much toxicant of the various materials to effect comparable kill in the field as in the laboratory. Such factors as high temperatures, sunshine, wide ranges in relative humidity, dew, or a combination of these factors greatly reduced the toxicity of the insecticides tested. Toxaphene, TM-1, dieldrin and EPN retained their toxicity for weevils under these environmental conditions better than the other materials tested. The toxicity of parathion, TM-4049, TM-711, BHC-DDT, TM-269, and aldrin was greatly reduced by the environmental factors listed above.

It was found that it required higher dosages of the insecticides to effect control of weevils late in the season than early in the season. Factors other than environmental effected the toxicity of organic insecticides to boll weevils. Here again, the food upon which the weevils develop may be partially responsible for this resistance to insecticides late in the season.

Toxaphene and TM-1, a chlorinated terpene, were equally effective against the boll weevil and leafworm.

1952 - Hanna, R. L., and J. C. Gaines. Evaluation of dusting schedules for control of cotton insects. J. Econ. Ent. 45(3):549.

There was no significant difference in the total yield between any two treatments or treatment combinations. This was probably due to extremely dry, hot weather and light weevil and bollworm damage. However, a significantly higher percentage of the total yield was harvested during the first picking from those plots which received early treatment.

1952 - Lincoln, C., and F. Williams. Control of cotton bollworms and boll weevil in 1951. Ark. Agr. Expt. Sta. Rpt. Ser. 33, 25 p. Apr.

Gamma BHC (0.3 lbs./ac), Calcium arsenate (7-10 lbs./ac), toxaphene (2.0 lbs./ac), dieldrin (0.15 lbs./ac), aldrin (0.25 lbs./ac), and heptachlor, all were effectively used in boll weevil control. Heptachlor, 0.25 to 0.35 lbs./ac was effective. Spraying was satisfactory.

Roussel, J. S., L. D. Newsom, and C. E. Smith. Insecticide tests for the control of cotton pests in Louisiana during the period 1948-51. Assoc. So. Agr. Workers 1952 Proc., 49th Ann. Conv., p. 81.

When DDT was added to either aldrin, gamma isomer benzene hexachloride, dieldrin, or heptachlor, satisfactory control of the boll weevil-bollworm complex was obtained.

1952 - Swain, R. B. Insect problems in Nicaragua. F.A.O. Plant Prot. B. 1(2):27-28, Rome.

A. grandis was very destructive in Nicaragua in 1951 and again in Sept. 1952 when plants were 3-6 weeks old. The weevils were controlled by early and late applications of Folidol E605, toxaphene, DDT-aldrin, DDT-chlordane, and BHC-DDT-sulfur. Early treatment was made when the plants were in the 4-leaf stage and when infestations of boll weevil reached 10%- 25% applications made every 3-5 days.

Young, M. T., and R. C. Gaines. Insecticide tests for control of the boll weevil, bollworm, cotton aphid, and two-spotted spider mite on cotton. So. Agr. Workers Assoc. Proc., 49th Ann. Conv., p. 81.

In experiments at Tallulah, La., in 1951, using 0.1-acre field plots in randomized blocks with 4 replicates, dust mixtures containing 1.25%, 2.50%, or 5.00% aldrin with 5% DDT and 40% sulfur, dust mixtures containing .75%, 1.50%, or 3.00% dieldrin with 5% DDT and 40% sulfur, and a dust mixture containing 2.50% heptachlor, 5% DDT and 40% sulfur gave good control of the boll weevil. Five different mixtures containing 3% or 6% of gamma benzene hexachloride and 5% or 10% DDT, some with or without 40% sulfur or 4% aramite, and lime-free calcium arsenate with 2.5% or 5.0% DDT and 0.5% or 1.0% parathion, gave good control of the boll weevil. The benzene hexachloride-DDT mixtures gave a greater increase in yield than the lime-free calcium arsenate mixtures.

Toxaphene dust (20%) gave better boll weevil control and a greater increase in yield than toxaphene spray. Aldrin and dieldrin sprays, with and without DDT, gave good boll weevil control, but the dieldrin-DDT spray did not yield so well as the other sprays, since it caused a greater buildup of spider mites.

1953 - Berry, P. A., and L. Abrego. Insects and diseases affecting some crops in El Salvador. F.A.O. Plant Prot. B. 1(10):151-153. Rome.

The most injurious pest of cotton in El Salvador is _A. grandis_ Boh. which feeds and breeds through the year. Although it appears in any small planting, however isolated, no alternative food plants are known. Control is hindered by rain, which falls almost every day throughout the growing season. _H. armigera_ Hbn. also attacks cotton and breeds throughout the year, but, in the absence of insecticidal treatment against _A. grandis_ Boh., appears to be held in check by natural enemies. When insecticides are applied against _A. grandis_, additional treatments against _H. armigera_ are often necessary.

1953 - Blake, G. H., Jr. The effect of chemical control on insect infestation and on yield and quality of cotton. Assoc. So. Agr. Workers Proc., 50:11.

Experiments were conducted in Alabama in 1947 to determine the effect of chemical control on insect infestation and on yield and quality of cotton. Four of 6 insecticidal treatments tested caused significant increases in the yield of cotton over the check. The data indicated that bollworm infestations have more effect on yield than boll weevil infestations and that boll weevil infestations have more effect on yield of cotton than do infestations of the cotton aphid. The insecticidal treatments had no significant effect on lint percentage, grade, or staple length of cotton.

1953 - Calhoun, S. L., and E. W. Dunnam. Heptachlor and other insecticides for control of cotton pests. J. Econ. Ent. 46(1):157-158.

Two field experiments were conducted at Stoneville, Miss., to determine minimum dosages of heptachlor required for the control of the boll weevil and its effect on other cotton pests. Tractor equipment was utilized to apply dusts

and sprays. Dusts containing 2.5%, 3.5%, and 5.0% of heptachlor were compared with each other and also with dusts containing 2.5% aldrin, 1.5% of dieldrin, and impregnated BHC containing 3% of the gamma isomer. No significant difference in boll weevil control was obtained between concentrations of heptachlor or between heptachlor and any of the other insecticides.

Emulsion sprays containing heptachlor gave boll weevil control equal to that of aldrin and dieldrin and similar to that obtained with dusts in equivalent dosages. Control with BHC dusts and chlordane sprays was about the same. DDT at the rate of 0.5 pound per acre was included in each treatment from August 2 to September 4 for control of the bollworm. Apparently, heptachlor had very little effect on infestations of the cotton aphid and spider mites.

It is concluded from these experiments, and from other observations and tests made in 1949 and 1950, that heptachlor at 0.25 pound per acre, in either dust or spray, is sufficient for control of the boll weevil under the conditions existing at Stoneville, Miss.

1953 - Calhoun, S. L., and E. W. Dunnam. Endrin for control of cotton pests. J. Econ. Ent. 46(1):170-172.

Two field experiments with endrin for the control of cotton pests were conducted in the vicinity of Stoneville, Miss., in 1951. In experiment 1, endrin, applied at the rate of 0.2 pound per acre, was compared with a mixture of 0.2 pound of dieldrin plus 0.5 pound of DDT. Three gallons of emulsion per acre was applied with tractor-mounted spray equipment. Endrin control of the boll weevil was equal to that obtained with the dieldrin-DDT mixture, but it was slightly better controlling bollworms.

In experiment 2, endrin applied at the rate of 0.2 pound per acre was compared with an untreated check. Applications were made with airplane-mounted spray equipment at the rate of 1 gallon per acre. Endrin produced excellent control of the boll weevil and bollworms, compared with an untreated check.

1953 - Hanna, R. L., and W. J. Mistric, Jr. Effect of different treatment schedules for control of cotton insects. J. Econ. Ent. 46(4):641-644.

Replicated tests designed to evaluate the effectiveness of 1, 2, and 3 early-season insecticidal applications, both on a small-plot basis and on a larger plot basis, showed no significant differences in yield between the 3 treatment schedules and the control. The large-plot test indicated a slightly earlier fruiting for all plots receiving early treatment than for the control plots. Small-plot tests showed that an 8-day treatment interval did not compare favorably with a 4-day treatment interval under conditions of damaging boll weevil or bollworm infestation.

1953 - Ivy, E. E., C. F. Rainwater, A. L. Scales, and L. J. Gorzycki. Comparative effectiveness of the ethyl and methyl homologs of nine phosphorus compounds against four cotton pests. J. Econ. Ent. 46(4):630-633.

Findings supported the hypotheses made at the beginning of the study--namely, that the boll weevil is an exception to the general order of toxicity. Of the ethyl and methyl homologs of 9 phosphoric acid esters, the ethyl compound is usually more effective against the cotton aphid, the desert spider mite, or the cotton leafworm but not against the boll weevil. Exceptions were found with each species, however, and there appeared to be no consistent pattern to these exceptions, or to the variations in the relation between the dosages required for the 2 homologs against the different species.

Two important facts emerge from the study. In the first place, in the development of new phosphorus compounds for the control of the boll weevil, compounds having methyl substituents should receive priority. However, in view of the exceptions, in the absence of actual tests we should be very careful in making too broad generalizations or assumptions concerning the specific performance of any new compound.

1953 - Lukefahr, M. J., and J. C. Gaines. Control of immature stages of the boll weevil. J. Econ. Ent. 46(3):430-433.

Six chlorinated hydrocarbon insecticides and 4 phosphorus compounds were tested to determine their effect upon the developing weevils within the squares. In the laboratory experiments the insecticides varied in their toxicity to the developing weevils. In general, the chlorinated hydrocarbons produced a higher percentage of mortality than the phosphorus compounds. A higher percentage of weevils within the treated squares either died in the adult stage or were paralyzed.

The insecticides in the hanging square tests gave a marked reduction in control, in comparison with the laboratory tests. This was probably because the leaves prevented the spray from adequately covering the squares.

When the insecticides were used in the field at recommended dosages for the control of adult boll weevils, there was apparently no mortality or paralysis of the developing forms.

1953 - McGarr, R. L. Combinations of insecticides for control of the pink bollworm and other cotton insects in the Lower Rio Grande Valley. J. Econ. Ent. 46(6):1103-1105.

Treatments of DDT 1 - 1.5 lbs./ac plus methyl parathion 0.2 - 0.375 lbs./ac and DDT 1 - 1.5 lbs./ac plus metacide 0.2 - 0.375 lbs./ac applied from 3 to 11 times were effective against the boll weevil up to time of migration. The addition of dieldrin in the final applications gave good control of this insect. Both mixtures gave substantial reductions in the number of bolls infested and in the number of pink bollworm larvae per infested boll. There was practically no difference in the results between the two mixtures.

Conditions were suitable for recording yields in only 3 of the tests, since rain washed off 1 application in tests Nos. 1 and 5 and 2 in No. 6. In these tests both mixtures increased the yield to almost twice that in the untreated plots. The gains may be attributed about equally to the control of the pink bollworm and the boll weevil.

Cotton aphids, bollworms, cotton leafworms, and spider mites were also held in check with the combinations of insecticides. Both methyl parathion and metacide are promising materials, but the former would probably be preferable, since it is a little more effective against the boll weevil.

1953 - Mistric, W. J., Jr., and J. C. Gaines. Effect of wind and other factors on the toxicity of certain insecticides. J. Econ. Ent. 46(2):341-346.

Results of laboratory and field cage tests for boll weevil control indicate that it required from 2 to 3 times more of the various insecticides to kill comparable percentages of weevils in the field than in the laboratory. Such climatic factors as high temperatures, wider ranges in relative humidity, sunlight, dew, and wind were important in reducing the toxicity of the various insecticides in the field. When exposed to normal climatic conditions, both in the field and outside of the laboratory, dieldrin retained its toxicity.

It required from 2 to 3 times as much of the various insecticides to kill comparable percentages of boll weevils late in the season, as compared to early in the season.

There was no appreciable reduction in the toxicity of toxaphene, EPN, methyl parathion, and endrin to boll weevils following 0.5 inch of simulated rain applied to the plants soon after treatment. The toxicity of heptachlor was reduced appreciably by the simulated rain. Aldrin and heptachlor showed a greater reduction in toxicity due to the effects of rain than did any of the other insecticides studied for boll weevil control. These sprays were either washed off the plants or the rain caused a breakdown of the chemical.

Dew, alone, did not greatly reduce the toxicity of the insecticides.

When used to control the boll weevil, high temperature (116°F.) generally reduced the toxicity of toxaphene, EPN, aldrin, dieldrin, and heptachlor more than did low temperature (68°F.). Aldrin and heptachlor showed greater reduction in toxicity.

The toxicity of toxaphene and dieldrin, when used against the boll weevil, was not greatly reduced by a 24-hour exposure of treated plants to simulated wind (4.7 m.p.h.). The toxicity of aldrin was greatly reduced during the 24-hour period, even in the absence of wind.

1953 - Mistric, W. J., Jr., and J. C. Gaines. The toxicity of certain insecticides to the overwintered boll weevil. J. Econ. Ent. 46(2):350-352.

Laboratory and field cage tests were conducted to determine the effectiveness of toxaphene, aldrin, dieldrin, heptachlor and BHC when used to control the overwintered boll weevil. In the laboratory tests all of these insecticides gave effective control of the weevil, with the exception of heptachlor which was used at a low dosage. In the field cage tests dieldrin was the only insecticide tested that gave effective control of the overwintered weevil. The toxicity of toxaphene and aldrin was greatly reduced, while heptachlor and BHC proved ineffective.

It is generally agreed that overwintered weevils, due to their lowered resistance, can be satisfactorily controlled early in the season with relatively low dosages of certain organic insecticides. However, the results of this study indicate that when certain climatic conditions are favorable to the boll weevil and unfavorable for the insecticides, higher dosages of the insecticides may be needed to obtain effective control of the overwintered boll weevil.

1953 - Parencia, C. R., Jr., and C. B. Cowan, Jr. Control of the boll weevil and the bollworm with organic insecticides in 1952. J. Econ. Ent. 46(6):1034-1038.

Small-plot and large-scale field experiments comparing insecticides applied as dusts and as low-volume sprays were conducted at Waco, Tex., during 1952 for the control of late-season infestations of the boll weevil and the bollworm, Heliothis armigera (Hbn.).

In a small-plot experiment, an EPN-DDT spray applied at a rate of 0.5 or 0.625 pound of EPN plus 0.75 pound of DDT per acre gave boll weevil control equal to that obtained with a dust containing sufficient BHC to give 3% of the gamma isomer, 5% of DDT, and 40% of sulfur. Sprays applied at the following acre-dosages were equally effective in controlling the boll weevil: toxaphene 1.9 pound plus DDT 0.92 pound; aldrin 0.33 pound plus DDT 0.67 pound; endrin 0.33 pound; dieldrin 0.27 pound plus DDT 0.67 pound; and heptachlor 0.33 pound plus DDT 0.67 pound. In another small-plot experiment conducted for boll weevil control, lime-free calcium arsenate containing 1% of parathion, and 20% of toxaphene plus 40% sulfur dusts, and a 0.3-pound dosage of endrin spray produced a significant increase in yield over that produced by a 0.2-pound dosage. In a large-scale experiment, metacide applied in a spray at an average rate of 0.5 pound per acre gave slightly better boll weevil control than toxaphene plus DDT spray but failed to control bollworms. Lime-free calcium arsenate containing 1% of parathion showed a longer period of residual toxicity to boll weevils than 20% toxaphene plus 40% sulfur dust.

1953 - Parencia, C. R., Jr., and K. P. Ewing. Late-season control of boll weevil and bollworm with sprays and dusts in 1950. J. Econ. Ent. 46(1):108-112.

In 1950, several organic insecticides applied as low-volume sprays and as dusts were tested in small-plot and large-scale field experiments against late-season infestations of the boll weevil and the bollworm, Heliothis armigera (Hbn.). One large-scale airplane experiment was conducted in northern Texas, near Ladonia, and the other experiments were conducted in central Texas, near Waco.

The following dust treatments were equally effective in controlling the boll weevil: 20% of toxaphene plus 40% of sulfur; 10% of chlordane, 5% of DDT and 40% of sulfur; 2.5% of aldrin, 5% of DDT, and 40% of sulfur; 5% of DDT, 40% of sulfur, and enough benzene hexachloride to provide 3% gamma isomer in the finished dust; 5% of heptachlor and 5% of DDT; and 2.5% of dieldrin.

In one small-plot experiment, there was no significant difference in yield between plots dusted with a mixture of DDT, sulfur, and either benzene hexachloride or aldrin, and those sprayed with DDT plus benzene hexachloride, aldrin, or heptachlor. In another experiment, plots dusted with toxaphene or dieldrin

produced significantly higher yields than a plot sprayed with heptachlor-DDT. In the same experiment there was no significant difference in yield when dieldrin was applied as a dust and as a spray.

In one small-plot and one large-scale experiment, toxaphene dust gave better boll weevil control and higher increases in yield than sprays containing toxaphene, benzene hexachloride plus DDT, aldrin plus DDT, or dieldrin. Dieldrin applied as a boll weevil dosage did not give satisfactory control. Toxaphene was more effective against bollworms when applied as a dust than as a spray. In 4 large-scale experiments a 0.375-pound dosage of aldrin gave better boll weevil control and higher increases in yield than a 0.25-pound dosage. In a large-scale experiment with 3 replications of each treatment, aldrin-DDT spray applied by an airplane at the rate of 0.375 pound of each insecticide per acre gave significantly better boll weevil control and a significantly higher yield than a toxaphene spray applied at 3 pounds per acre.

1953 - Rainwater, C. F., E. W. Dunnam, E. E. Ivy, and A. L. Scales. Calcium carbonate as a diluent for insecticide dusts. J. Econ. Ent. 46(6):923-927.

Biological tests were conducted to determine the stability of insecticide dusts formulated with calcium carbonate as the diluent.

The calcium carbonate used was ground limestone that had been treated with a chemical reagent to produce a free-flowing, nonwettable powder. The dusts were held in storage in glass bottles at room temperature or in paper bags at 100% relative humidity, and tested at intervals for a year or more. Dusts of the same insecticides formulated with pyrophyllite were tested for comparison.

The only evidence of breakdown or loss in effectiveness occurred sometime between 6 and 14 weeks after the BHC-calcium carbonate dust had been held in paper bags at 100% relative humidity. After a slight loss, however, the mixture apparently remained stable during the rest of the 66 weeks in storage.

These tests indicate that the insecticides will remain stable when formulated in dusts with a free-flowing, nonwettable form of calcium carbonate and held under ordinary dry storage conditions for a year or more.

Dusting quality of formulations prepared with the special calcium carbonate was greatly improved over that of regular commercial dusts for application by ground machines and airplane.

In field tests, dusts containing 20% of toxaphene, and sufficient BHC to give 3% of the gamma isomer plus 5% of DDT formulated with this special calcium carbonate, gave just as good control of the boll weevil and the bollworm as the same toxicants, and others, prepared with commercial diluents.

1953 - Scales, A. L., E. E. Ivy, J. C. Gaines, and C. F. Rainwater. EPN for cotton insect control. J. Econ. Ent. 46(1):130-133.

The fact that EPN exhibited comparatively high toxic action against the boll weevil in field and greenhouse tests makes it a promising insecticide for use against cotton insects, and large-scale field experiments with it appear to be justified. The dosage indicated for boll weevil control, comparable to that obtained with 2 pounds of technical toxaphene or 10 pounds of calcium arsenate, is 0.3 pounds of technical EPN per acre. This dosage probably would also be very effective against the cotton leafworm.

The data indicate that, when used for boll weevil control at 0.3 pound per acre, EPN would give very good control of spider mites on cotton. Although this dosage was not highly effective against the cotton aphid, the data showed that mortality in excess of 50% might be expected. This degree of control might be expected to hold the cotton aphid in check, since that aphid is seldom a problem unless insecticides relatively ineffective against it are used to control other insects.

A serious drawback to the indicated use of EPN for control of cotton insects was its failure to control the bollworm at the dosage indicated as effective. Before EPN could compete with the insecticides recommended for overall control of cotton insects, it would almost certainly be necessary to add DDT to the dusts or sprays in such proportion that a minimum of 0.5 pound per acre of technical DDT would be applied.

1953 - Wene, George P. Control of migratory boll weevils in the Lower Rio Grande Valley of Texas. J. Econ. Ent. 46(6):1051-1053.

Dust mixtures of 2.5% dieldrin with 10% DDT and 3-10-40 were more effective than 20% toxaphene or 50% calcium arsenate-sulfur in controlling migratory boll weevils. Dieldrin was slightly more effective than the 3-10-40 dust.

As a spray, dieldrin at 0.29 pounds per acre was more effective than 0.5 pound of aldrin or EPN in controlling migratory boll weevils. Endrin at 0.2 pound per acre was also more effective than toxaphene at 3 pounds or EPN at 0.75 pound against the adult boll weevil.

During boll weevil migration the intervals between applications should be shortened to 3 or 4 days.

1953 - Young, M. T., and R. C. Gaines. Insecticide tests for control of the boll weevil, bollworms, cotton aphid and two-spotted spider mite on cotton. Assoc. So. Agr. Workers Proc. 50:112.

Dimethyl homolog of parathion (2%) plus DDT (5%) did not satisfactorily control the boll weevil. The remaining treatments (aldrin-DDT, dieldrin-DDT, heptachlor-DDT, toxaphene-DDT-sulfur, 3-5-40, 3-5-40 alternated with calcium arsenate, toxaphene 20-sulfur 40) all gave good boll weevil and bollworm control and a small increase in yield. In 2 experiments, 12 sprays (aldrin-DDT, dieldrin-DDT, toxaphene-DDT, toxaphene, heptachlor-DDT, 2 brands of BHC-DDT, endrin, aldrin plus endrin, dieldrin plus endrin, EPN plus DDT, and metacide) when compared with 3-5-40 alternated with calcium arsenate, toxaphene 20% or toxaphene 20% plus sulfur 40%, all gave good boll weevil and bollworm control followed by increased yields.

1953 - Young, M. T., and R. C. Gaines. Tests of insecticides for control of cotton insects. J. Econ. Ent. 46(1):133-136.

Toxaphene dust, and aldrin and dieldrin sprays gave satisfactory control of the boll weevil. The toxaphene spray was less satisfactory, particularly during the latter part of the season. Toxaphene dust and aldrin and aldrin-DDT sprays gave significant increases in yields over dieldrin-DDT spray, probably owing to a much greater buildup of mites in the dieldrin-DDT plots.

Compound 269 gave very little control of the boll weevil and a very small increase in yield.

1953 - Young, M. T., and R. C. Gaines. Control of insects and spider mites on cotton in 1952. J. Econ. Ent. 46(4):693-696.

Chlorinated hydrocarbons reduced the boll weevil as much as 49% to 62%. Inclusion of phosphates, aramite, etc., reduced infestation by 34% to 39%.

1954 - Arant, F. S. Experiments for control of cotton insects in 1953. Assoc. So. Agr. Workers Proc. 51:94.

Endrin at the rate of 0.375 pound per acre reduced the boll weevil infestation to a lower level than any other treatment used. Chlorthion at 0.75 pound per acre, methyl parathion at 0.375 pound per acre, and malathion at 3 pounds per acre, each in mixtures containing 0.75 pound DDT per acre, were satisfactory in controlling boll weevils during a season of mild temperatures and heavy weevil infestation.

1954 - Brown, E. C., Jr., and R. L. Hanna. Amount of spray per acre for the control of cotton boll weevils and bollworms. Tex. Agr. Expt. Sta. Prog. Rpt. 1687. May 31.

Tests were conducted in the Brazos River Valley in 1950-1953 to compare the effectiveness of 3 different quantities of liquid sprays per acre applied with 3 nozzles per row. An equal amount of active insecticide was applied to all test plots. Two gallons of spray per acre was as effective as 6 or 14 gallons, as measured by yield and infestation.

1954 - Fenton, F. A., J. R. Dogger, and G. A. Bieberdorf. Boll weevil and bollworm control with insecticides. Okla. Agr. Expt. Sta. B. B-441, 22 p. Nov.

Five years' results with 14 insecticides were evaluated as sprays or dusts. There was no difference in effectiveness between sprays or dusts.

1954 - Fife, L. C., and R. L. Walker. Comparative effectiveness of various phosphorus and chlorinated hydrocarbon insecticides for control of cotton pests. J. Econ. Ent. 47(5):803-807.

Several phosphorus compounds and chlorinated hydrocarbon insecticides were tested against the boll weevil, Anthonomus grandis Boh., the cotton aphid, Aphis gossypii Glov., the cotton leafworm, Alabama argillacea (Hbn.), the desert spider mite, Tetranychus desertorum Banks, and the two-spotted spider mite, T. bimaculatus Harvey, at Florence, S.C., in 1953.

The new insecticides, methyl parathion, chlorthion, EPN, endrin, isodrin, and Strobane were compared with the recommended insecticides BHC, heptachlor, toxaphene, aldrin, and dieldrin.

Methyl parathion applied at 0.25 pound or more per acre, both in a dust or spray, and a 2.5 percent chlorthion dust gave satisfactory control of the over-wintering brood of boll weevils but were less effective against the summer broods than the standard insecticides applied at the recommended rates.

At 0.35 and 0.5 pound per acre chlorthion in a dust, and methyl parathion, in both dusts and sprays, usually gave good seasonal control of the boll weevil.

In 2 out of 3 experiments, yields were lower in the chlorthion-treated plots, regardless of the dosage used, than in plots treated with the chlorinated hydrocarbon insecticides.

The results with EPN were somewhat erratic; at 0.5 pound per acre, in both a dust and spray, it was effective against the overwintering brood of boll weevils but against the summer-brood weevils the results were not consistent.

Strobane at 2 pounds per acre gave effective seasonal control of the boll weevil. In 2 experiments the addition of DDT to Strobane increased the effectiveness of the treatment.

Endrin gave good seasonal boll weevil control at 0.2 pound per acre, and at 0.3 pound it was outstanding.

Isodrin compared favorably with endrin at the same dosage level for boll weevil control.

1954 - Hanna, R. L. Application schedules for control of cotton insects. J. Econ. Ent. 47(6):1129-1131.

Small-plot test of factorial design conducted to evaluate early-season and late-season application schedules for cotton insect control showed a significantly lower population of thrips and a higher yield as a result of 3 early-season applications of insecticide. Seven late-season applications at 5-day intervals resulted in significantly higher yield than 5 late-season applications at 7-day intervals. A replicated large-plot test designed to test the relative effectiveness of 1, 2, and 3 early-season applications of insecticides showed a significant reduction of numbers of thrips due to 3 early-season applications of insecticides but no appreciable increase in yield.

1954 - Ivy, E. E., A. L. Scales, and L. J. Gorzycki. Three new phosphate insecticides for the systemic control of cotton insects. J. Econ. Ent. 47(6):1148-1149.

Three compounds, TM 12008, TM 12009, and TM 12013, were applied to cotton seed at the rate of 4 pounds per 100 pounds of seed. Results of tests against the boll weevil and the cotton leafworm are presented. Each compound was highly effective on seedlings infested 1 week after treatment, but TM 12008 (0,0-diethyl S-isopropyl mercaptomethyl dithiophosphate) retained its toxicity for the longest time.

1954 - Merkl, M. E., and E. W. Dunnam. Tests against cotton pests with some new dust and spray formulations. J. Econ. Ent. 47(5):869-871.

At Stoneville, Miss., several organic insecticides formulated with a new chemically treated calcium carbonate had excellent dusting qualities and gave

good control of cotton insects. A stabilized endrin dust gave less promising results, owing to poor distribution on plants. Some repellency was noted and attributed to the liberation of ammonia and other gases from the ammonium carbonate and urea used as stabilizers in the endrin formulation.

Two new phosphorus compounds, OS-1836 (2-chlorovinyl diethyl phosphate) and OS-2046 (2-carbomethoxyisopropenyl dimethyl phosphate), in sprays gave substantial reductions in populations of several cotton insects.

1954 - Mistric, W. J., Jr., and J. C. Gaines. Effect of weather factors on the toxicity of certain insecticides. J. Econ. Ent. 47(4):646-651.

Laboratory cage experiments were conducted to determine the effect of wind on the toxicity of emulsion sprays of toxaphene, dieldrin, and endrin when used to control the boll weevil. Similar experiments were also conducted to determine the effect of wind on the toxicity of toxaphene, aldrin, dieldrin, and endrin when used to control the salt-marsh caterpillar.

The results from the experiments with these 2 insects were strikingly similar. Simulated wind reduced the toxicity of toxaphene more than that of the other materials tested. However, in the absence of wind the toxicity of toxaphene was reduced less than any of the other insecticides used. Wind, therefore, appeared to be the more important climatic factor studied which reduced the toxicity of toxaphene. Wind was not an important factor in reducing the toxicity of aldrin because aldrin lost its toxicity very rapidly, even in the absence of wind. The toxicities of dieldrin and endrin were reduced appreciably by simulated wind. Both the immediate and residual toxicity of endrin were slightly superior to that of dieldrin. An increase in wind movement slightly decreased the toxicity of insecticides, at least within the range of wind velocities tested. The effect of wind was not dependent on the dosage of insecticides applied in these tests.

1954 - Rea, James M., A. L. Hamner, and Ross E. Hutchins. Some effects of aldrin, BHC-DDT, dieldrin, and toxaphene on the boll weevil. J. Econ. Ent. 47(1):48-53.

The data obtained under laboratory conditions indicate that:

Toxaphene and dieldrin gave appreciably better control of boll weevils than aldrin or BHC-DDT when applied either as a dust or spray.

BHC-DDT gave better control as a dust than as a spray. Dust formulations of aldrin, dieldrin, and toxaphene tended to give better control than sprays.

Toxaphene gave better and faster control than the other insecticides when not subjected to simulated rainfall.

One-half inch of simulated rainfall significantly reduced the control by all insecticides when applied as a dust or spray, except in the case of dieldrin applied as a spray. Dieldrin and toxaphene gave almost the same control after exposure to 0.5 inch of simulated rain.

A dust formulation containing 20% toxaphene, 30% Attaclay, and 50% Pyrax was reduced in activity by simulated rainfall to a lesser extent than 3 other dust formulations.

The egg-laying and feeding activities of female boll weevils were reduced by exposure to lethal dosages of toxaphene, even when exposed for only 2 hours.

1954 - Smith, G. L., C. A. Richmond, and L. W. Noble. Mixtures of DDT and other insecticides for control of pink bollworms and boll weevils in southern Texas. J. Econ. Ent. 47(1):177-178.

Five large-scale insecticide experiments were conducted in southern Texas in 1952 to evaluate mixtures of DDT with other insecticides for the control of the pink bollworm, Pectinophora gossypiella (Saund.), and the boll weevil. The insecticides used with DDT were EPN, dieldrin, BHC, or toxaphene. All the mixtures increased the yield of seed cotton, the higher increases resulting from control of the pink bollworm. The addition of DDT to dieldrin caused considerable increase in boll weevil control over that obtained with dieldrin alone. The addition of EPN to DDT increased pink bollworm control and gave satisfactory control of the boll weevil.

1954 - Young, M. T., and R. C. Gaines. Control of insects and spider mites on cotton in 1953. Assoc. So. Agr. Workers Proc., 51:94.

Calcium arsenate, various organic insecticides, and mixtures of these materials were tested in 1/10-acre plots at Tallulah, La., in 1953 for control of the boll weevil, the bollworm, the cotton aphid, the cotton fleahopper, and 2 species of spider mites. All mixtures containing either BHC, heptachlor, aldrin, dieldrin, methyl parathion, and chlorthion plus DDT applied either as dusts or sprays satisfactorily controlled the boll weevil, cotton aphid, bollworm, and the cotton fleahopper. Metacide spray controlled the boll weevil but when used as a 2% dust was not very effective. Dusts with Strobane 20%, toxaphene 20%, toxaphene 20% plus sulfur 20%, 3-5-40 alternated with calcium arsenate, and endrin spray satisfactorily controlled the boll weevil, bollworm, and the cotton fleahopper.

1955 - Dogger, James R. Solutions of insecticides in an isoparaffinic oil for cotton insect control. J. Econ. Ent. 48(4):422-424.

An oil known as HFA No. 1, or Soltrol 180, was not phytotoxic to cotton when applied in the field at rates up to 7.5 gallons per acre. Insofar as cotton insect control was concerned, no decrease in effectiveness of dieldrin-DDT, endrin, and heptachlor was evident when they were applied in a solution of this oil. Rates of application for oil solutions of 2 to 4 gallons per acre appeared to be effective on cotton under Oklahoma conditions.

While the oil itself proved nonphytotoxic, solutions of the various insecticides in the oil had various detrimental effects on the plants. Toxaphene in HFA No. 1 solution, at rates normally applied under field conditions, was highly injurious to cotton plants. Heptachlor in the oil solution caused moderate injury to young cotton plants from which they were able to recover. Older plants showed less injury when sprayed at practical field rates.

Aldrin, dieldrin plus DDT, and endrin in HFA No. 1 solutions were nonphytotoxic to cotton at practical rates of application.

1955 - Ivy, E. E., J. R. Brazzel, A. L. Scales, and D. F. Martin. Two new phosphate insecticides for cotton insect control. J. Econ. Ent. 48(3):293-295.

Bayer 17147, a benzotriazine derivative of a methyl dithiophosphate, appeared promising in laboratory tests against the boll weevil, cotton aphid, spider mite, bollworm, cotton leafworm, brown cotton leafworm, flower thrips, cotton fleahopper, and pink bollworm.

Bayer 16259, a benzotriazine derivative of an ethyl dithiophosphate, in laboratory tests was more effective than 17147 against the salt-marsh caterpillar, cotton aphid, and spider mite, but was less effective against the boll weevil.

The residual toxicity of Bayer 17147 was greater than that of toxaphene.

1955 - McGarr, R. L. Weekly applications of insecticides for control of the pink bollworm and the boll weevil. J. Econ. Ent. 48(1):95-96.

Tests near San Benito, Tex., consisted of 4 series of spray tests. DDT was used with endrin, methyl parathion, heptachlor, BHC, chlorthion, and a mixture of endrin and methyl parathion. Demeton was also used in some tests. Although boll weevils were light in 2 of the series, the DDT-endrin and endrin-methyl parathion mixtures seemed promising.

A single large-scale test was conducted at San Fernando, Mex., in which endrin was compared with a mixture of dieldrin, DDT, and parathion. Eight applications were made at weekly intervals using emulsifiable concentrates. Both treatments gave very good control of the boll weevil and good yield increases under rather severe conditions.

1955 - Robertson, R. L., and F. S. Arant. Effect of Bayer 17147 on boll weevil. J. Econ. Ent. 48(5):604-605.

Experiments were conducted to determine the effect of Bayer 17147 on adults of the boll weevil. Five percent Bayer 17147 and 20% toxaphene were applied to foliage of cotton in the field as dusts at the rates of 10 and 20 pounds per acre.

Insects were exposed in petri dishes to leaves taken from each plot immediately and at 24-hour intervals for 12 days after application. The initial kill was more rapid and residues which resulted in mortality persisted longer on plants treated with Bayer 17147 than on plants treated with toxaphene.

1956 - Arant, F. S., and R. L. Robertson. Field experiments with nonsystemic insecticides for control of cotton insects. Assoc. So. Agr. Workers Proc. 53:128.

Replicated small-plot experiments were conducted with dusts and sprays for control of cotton insects. Insecticides were applied with high-clearance tractor equipment. Seven applications were required during the season. Bayer 17147 gave excellent control of the boll weevil at rates of 0.25, 0.37, and 0.50 pound per acre. Endrin at the rate of 0.37 pound per acre gave excellent control of the boll weevil and the bollworm. Several other insecticides gave satisfactory results.

1956 - Cowan, C. B., Jr., C. R. Parencia, and J. W. Davis. Late-season control of the boll weevil and the bollworm with new insecticides in 1955. J. Econ. Ent. 49(6):783-785.

Small-plot and large-scale experiments with several insecticides applied as dusts and as low-volume sprays were conducted in central Texas during 1955 for the control of late-season infestations of the boll weevil and the bollworm, Heliothis zea (Boddie).

In several experiments, Bayer 17147 gave excellent boll weevil control at 0.25 and 0.375 pound per acre. In one experiment 0.125 pound of 17147 and 0.25 pound of Bayer 16259 were less effective. In another experiment Strobane and chlorthion were less effective than toxaphene, and Bayer L 13/59 was ineffective. Dieldrin at 0.43 pound per acre compared favorably in control and yield with Bayer 17147 at 0.36 pound in a large-plot experiment. DDVP dusts and sprays, with or without Aroclor, were ineffective at the dosages used.

1956 - Early, Jack D., and James H. Cochran. Insecticidal evaluation of organic arsenical compounds. J. Econ. Ent. 49(2):239-242.

Evaluation of 39 organic arsenical compounds in the laboratory for their insecticidal properties, using boll weevils, rice weevils, southern armyworm larvae, and cotton leafworm larvae, as test insects. Arsenated toxaphene possessed the highest degree of toxicity and was more effective than toxaphene against the boll weevil. Several other compounds exhibited a high degree of toxicity but some were phytotoxic.

1956 - Lincoln, Charles, and T. F. Leigh. Time of day and frequency of insecticidal application in relation to control of the cotton boll weevil. Assoc. So. Agr. Workers Proc. 53:127.

Midday and late afternoon applications of insecticides to control the cotton boll weevil were compared in replicated plots. Daytime applications were made between 9 a.m. and 5 p.m. and nighttime applications between 5 p.m. and 8 p.m. Daytime applications included toxaphene dust and heptachlor granules. Applications at night included endrin dust and 3-5 (BHC-DDT) dust. Satisfactory control was obtained with midday applications of all materials, although the efficiency of BHC dust was somewhat reduced. Four-day and 7-day application frequencies were tested in replicated plots using 3-5-40 (BHC-DDT-S), $2\frac{1}{2}$-5-40 (heptachlor-DDT-S), endrin, and calcium arsenate as dusts applied with ground equipment. Satisfactory control of the cotton boll weevil was obtained with all materials and at both frequencies, but some difference in degree of control was experienced.

1956 - Mistric, W. J. Effect of sunlight and other factors on the toxicity of certain insecticides. J. Econ. Ent. 49(6):757-760.

Laboratory experiments were conducted at College Station, Tex., during 1954 to determine the effects of climatic factors, insecticidal dosage levels, and multiple insecticidal applications on the effectiveness of certain insecticides used to

control the boll weevil and the cotton leafworm, Alabama argillacea (Hbn.). Results of this study were as follows:

(1) BHC, heptachlor, and aldrin were completely ineffective in controlling the boll weevil following a 24-hour exposure of treated plants to 0.87 inch of natural rainfall. Appreciable control was obtained with toxaphene and dieldrin under these conditions.

(2) A 24-hour exposure of treated plants in outdoor shade at high temperature greatly reduced the residual effectiveness of BHC, heptachlor, and aldrin when used to control the boll weevil. High temperature alone caused practically a total loss in insecticidal toxicity; hence, sunlight was not an important factor in reducing the effectiveness of these materials. Toxaphene and dieldrin retained considerable toxicity in outdoor sunlight at high temperature. Sunlight did not affect the toxicity of toxaphene, while it was an important factor in reducing the toxicity of dieldrin.

(3) Increased dosages of toxaphene, BHC, heptachlor, and endrin slightly increased the initial control of the boll weevil, but not sufficiently to justify the use of the increased dosages. When treated plants were exposed for 48 hours to outdoor weather conditions, BHC and heptachlor were virtually ineffective, while endrin retained a small degree of toxicity. Toxaphene retained considerable toxicity under these conditions.

(4) Repeated applications of either toxaphene or BHC at 5-day intervals did not result in accumulated toxic residues which could be measured in terms of either initial or residual control of the boll weevil.

(5) When treated plants were exposed for 24 hours, indoors or outdoors, the toxicity of chlorthion to the boll weevil was reduced slightly more than that of toxaphene. Strobane compared very favorably with toxaphene in both initial and residual control. The residual effectiveness of Bayer 17147 at a low dosage was far superior to that of toxaphene.

(6) The effectiveness of parathion or endrin in controlling the cotton leafworm was reduced to a greater extent than that of toxaphene or calcium arsenate during a 24-hour exposure of treated plants to natural climatic conditions in the absence of rainfall. However, all of these materials exhibited good residual properties under the conditions of the experiment. One-half inch of simulated rainfall applied immediately after insecticide applications was slightly more detrimental to toxicant effectiveness than rain occurring 24 hours after treatment. Rain slightly reduced the toxicity of toxaphene and parathion, appreciably reduced the toxicity of endrin, and greatly reduced the toxicity of calcium arsenate.

1956 - Pfrimmer, T. R., and R. C. Gaines. Field tests with insecticides against cotton at Tallulah, La., in 1954. J. Econ. Ent. 49(1):72-74.

Five experiments were conducted in plots arranged in randomized blocks, with 4 replications of each treatment. Chlorinated hydrocarbons (dieldrin-DDT, dieldrin-DDT-sulfur, dieldrin-DDT-parathion, heptachlor-DDT, heptachlor-DDT-sulfur, aldrin-DDT-sulfur, BHC-DDT, BHC-DDT-sulfur, BHC-DDT-parathion) all satisfactorily controlled the boll weevil. Several dust mixtures containing 3% gamma BHC gave some control but was not as good as expected. American Cyanamid 12008 and 12009 (0.25 and 0.29 lbs./ac) and chlorthion were unsatisfactory in control of the boll weevil. Heptachlor, endrin, and Strobane (0.28, 0.30 and 2.8 lbs./ac) were satisfactory.

1956 - Pfrimmer, T. R., and R. C. Gaines. Field tests with new materials against cotton insects at Tallulah, Louisiana during 1955. J. Econ. Ent. 49(5):712-713.

In spray plots, Bayer 17147 had a significantly lower weevil infestation than chlorthion, Bayer L 13/59, Strobane, and toxaphene. Strobane and toxaphene had significantly higher yields.

Bayer 17147 (2.5% and 5%) gave significantly better boll weevil control in a series of dust treatments. Endrin plus sulfur and endrin alone gave significantly better control than DDVP, DDVP plus Aroclor (a chlorinated polyphenyl), or Bayer L 13/59 at 2 strengths. The last 4 dust treatments did not differ from the check. All insecticides except endrin alone held the spider mite population significantly lower than the check.

Two spray formulations of Am. Cyanamid 3911 were applied three times to the foliage at an average rate of a little over 2 pounds of the technical material per acre. Both formulations gave some control of the boll weevil and prevented an aphid buildup but did not increase the yield.

1956 - Rainwater, C. F. Bayer 17147, a promising new insecticide for cotton insects. Agr. Chemicals 11(2):32-33.

Results of tests at Brownsville, College Station, and Waco, Tex.; Tallulah, La.; Stoneville, Miss.; and Florence, S.C.

1956 - Richmond, Clyde A. Tests with phosphorus insecticides for control of pink bollworm and some other cotton pests, 1955. J. Econ. Ent. 49(6):874.

The following sprays were tested: Bayer 17147, Bayer 17147-DDT, dieldrin-DDT, and endrin. All the insecticides gave good control of the boll weevil and were equally effective.

1956 - Siddiqi, A. A. Studies on the residual toxicity of certain organic insecticides for the control of the boll weevil (Anthonomus grandis Boh.). Indian J. Ent. 18(1):45-48.

In tests in Louisiana, laboratory-reared adults of Anthonomus grandis were caged on cotton plants immediately after, or 24 or 48 hours after the plants had been sprayed. They were examined for mortality 48 hours after being caged. The results showed that applications of 0.2 lb. of endrin, 2.0 lbs. of toxaphene, and mixtures of 0.5 lb. of DDT with 0.15 lb. of dieldrin or 0.3 lb. of gamma BHC per acre, all significantly reduced insect populations. There was no significant difference between the first 3 in immediate or residual effect, though endrin seemed to be the most toxic. The first 3 were significantly better than the BHC mixture.

1956 - Walker, J. K., Jr., B. G. Hightower, R. L. Hanna, and D. F. Martin. Control of boll weevils resistant to chlorinated hydrocarbons. Tex. Agr. Expt. Sta. Prog. Rpt. 1902. Nov. 7.

Chlorinated hydrocarbon insecticides failed to give commercial control in several fields in the Brazos River Valley in 1956. Calcium arsenate and several phosphorus compounds were effective.

1956 - Walker, R. L., and A. R. Hopkins. Studies on the control of boll weevils in surface woods trash. J. Econ. Ent. 49(5):696.

A large-scale field experiment and a cage experiment were conducted in South Carolina in 1954 and 1955 to determine the effectiveness of granulated insecticides applied to surface woods trash to control overwintering boll weevils. In the large-scale experiment, aerial applications made to surface woods trash in a small agricultural community reduced boll weevil populations considerably. The cage experiment demonstrated that a high kill of overwintering weevils could be obtained in this manner.

1957 - Blum, Murray S., Norman W. Earle, and John S. Roussel. The metabolism of DDT in the boll weevil (Anthonomus grandis). Ent. Soc. Amer. B. 3(3):226. Sept. 1957.

Rates of penetration of DDT in weevils of different ages and strains. Penetration is slowest in overwintering weevils and fastest in weevils 1-2 days old. No differences are observed in the penetration rates in chlorinated hydrocarbon resistant and susceptible weevils. A large percentage of the penetrated DDT is converted to a metabolite which does not respond to the Schechter-Haller test. DDE is produced in trace amounts, but neither DDE or DDA are metabolized appreciably by the weevil. DDT synergists, when applied either topically or by injection with DDT, show negligible activity. However, DDT is substantially more toxic to the weevil when injected, as compared with topical application. The topical LD_{50} of DDT varies with the age of the weevil and with the strain examined. The ineffectiveness of DDT as a weevil insecticide is discussed in relation to these results.

1957 - Burkhalter, G. F., and F. S. Arant. Boll weevil resistance in Alabama. Assoc. South. Agr. Workers Proc. 54:143.

Laboratory tests were conducted during the 1956 season to determine the susceptibility of 2-day-old boll weevils to chlorinated hydrocarbon insecticides. Weevils reared from squares collected at Courtland, Lownsesboro, Frisco City, Fairhope, and Auburn were treated topically with approximately 1 microliter of toxaphene, endrin, or Guthion solution. Mortality counts were made 72 hours after treatment. Boll weevils from Fairhope were more susceptible to toxaphene than those from the other 4 localities. The LD-50 of the most resistant strain was only about 5 times that of the Fairhope strain. There was little evidence of resistance to endrin and none to Guthion.

These studies revealed no evidence of acute resistance of the boll weevil to any insecticide studied. There was evidence of an incipient resistance to toxaphene, an insecticide used for a longer period than any other chlorinated hydrocarbon on cotton in Alabama.

1957 - Clower, D. F., J. S. Roussel, and H. Hardwick. Results of studies utilizing granular formulation of insecticides for boll weevil control. Assoc. So. Agr. Workers Proc. 54:145.

Granular formulation of some insecticides applied to the soil resulted in control of boll weevils susceptible to the chlorinated hydrocarbons, but failed to control boll weevils resistant to these insecticides. Guthion did not control boll weevils by this method of application. Thimet applied in granular formulation as a side dressing was not effective for boll weevil control.

1957 - Cowan, C. B., Jr., J. W. Davis, and C. R. Parencia, Jr. Control of the boll weevil and bollworm with chlorinated hydrocarbon and phosphorus insecticides in 1956. J. Econ. Ent. 50(5):663-666.

During 1956 experiments were conducted with chlorinated hydrocarbon and phosphorus insecticides applied as dusts and as low-volume sprays on irrigated cotton in central Texas for the control of late-season infestations of the boll weevil and the bollworm (Heliothis zea (Boddie)).

In several experiments, 0.25 lb. and 0.375 lb. of dust and spray dosages of Guthion gave good boll weevil control. EPN and methyl parathion at 0.5 lb. per acre were as effective as endrin at 0.36 lb. Dipterex at 2 lbs. per acre was ineffective. Thiodan at 0.5 to 0.6 lb. per acre showed promise in this control.

1957 - Furr, R. E., M. E. Merkl, and E. P. Lloyd. Toxicity of organic insecticides to the boll weevil by topical application. Assoc. So. Agr. Workers Proc., p. 54:144.

Results of topical applications using aldrin, BHC, dieldrin, endrin, Guthion, heptachlor, methyl parathion, thiodan, and toxaphene in 1 microliter doses to adult boll weevils.

Field-collected weevils from 4 different localities in the State were topically treated, and the materials used were compared as to location. LD-50 values are presented for each material where it was possible to obtain such values.

1957 - Gaines, J. C. Cotton insects and their control. Ann. Review of Ent. 2:322-325.

A brief summary of the spread of the boll weevil in the United States and the development of measures for control.

1957 - Ivy, E. E., A. L. Scales, and L. J. Gorzycki. A new systemic insecticide for cotton insects. J. Econ. Ent. 50(5):698-699.

In a screening program at College Station, Tex., several promising systemic insecticides were discovered. These materials were applied to cotton seed before planting, and were tested against several cotton insects. The systemic action of thimet persisted longer than that of the other compounds. This was particularly true in the case of boll weevils, thrips, and cotton leaf perforators. No plant injury from thimet was apparent in seed treated at 8 or 4 lbs. per 100 lbs. of seed.

1957 - Lincoln, C. and T. F. Leigh. Timing insecticide applications for cotton insect control. Ark. Agr. Expt. Sta. B. 588. May.

Ten years of research work relating to timing of applications of insecticides to cotton. Applications of insecticides for boll weevil control greatly increased yields of cotton when infestations were heavy and conditions favorable for fruiting of cotton plants. When infestations are low or conditions unfavorable for fruiting, applications of insecticides do not increase yields of cotton. In general, using insecticides in such a manner as to maintain a seasonal average infestation of 40% punctured squares maintained yields and cost less than more frequent applications.

Irrigation creates favorable conditions for the boll weevil and increases fruiting and potential yield of the cotton. Boll weevil control may be quite profitable on irrigated cotton when it would not pay on nonirrigated cotton.

1957 - McGarr, R. L. Tests with Insecticides for control of cotton insects in the Lower Rio Grande Valley. J. Econ. Ent. 50(5):632-634.

TESTS IN 1948.--Treatments satisfactorily reduced the boll weevil populations. The greatest reduction was induced by chlordane plus sulfur. The best increase in yield was obtained from the treatment of calcium arsenate plus sulfur, this being closely followed by all the other treatments except the chlordane plus sulfur which seemed to have an adverse effect on the plants.

Treatments with calcium arsenate, alone and in combination with sulfur and parathion, gave about equally effective control of weevils and practically the same substantial increases in yield. Although BHC plus DDT and sulfur, and BHC plus methoxychlor and sulfur gave only fair reductions in boll weevils, the former was superior in yield due to control of a bollworm infestation.

TESTS IN 1950.--Dieldrin dust and spray gave good control of the boll weevil infestations, whereas reductions for toxaphene plus sulfur and calcium arsenate plus sulfur were noticeably lower. Toxaphene was included in a spray at 3 lbs. per acre, but it failed to give satisfactory results after 3 applications, and its use was discontinued. The dieldrin spray was the only spray used throughout the season. It gave good control of the boll weevil, but the plants did not seem to fruit as well as where the dieldrin-sulfur dust was used.

In a second series, treatments of low-lime calcium arsenate plus parathion and BHC, heptachlor plus sulfur, aldrin plus sulfur, and calcium arsenate plus sulfur, all substantially reduced boll weevils. The heptachlor-sulfur effected the greatest weevil reduction, and calcium arsenate-sulfur, the least.

TESTS IN 1952.--In a spray series with Metacide, methyl parathion, heptachlor, endrin, and dieldrin, endrin gave very good control of both the boll weevil and the bollworm, followed closely by dieldrin. Methyl parathion gave only fair control of the boll weevil under heavy infestations late in the season. Metacide was not quite so good as methyl parathion, and heptachlor was the poorest of all the materials.

TESTS IN 1953.--In one dust series the best reduction of boll weevils was obtained with low-lime calcium arsenate containing 1% methyl parathion. All the other treatments, 2.5% heptachlor plus sulfur, 5% heptachlor plus sulfur, methyl parathion plus DDT, and dieldrin plus sulfur gave satisfactory control, except the 2.5% heptachlor and sulfur, where the control was only fair. The greatest yield was from the methyl parathion plus DDT, followed by the low-lime calsium arsenate plus methyl parathion and the dieldrin plus sulfur.

TESTS IN 1954.--Dust treatments of low-lime calcium arsenate plus methyl parathion, endrin, dieldrin plus methyl parathion and DDT, and dieldrin plus sulfur, all gave satisfactory control of the boll weevil under moderate infestations.

The best increase in yield was from the dieldrin-methyl parathion-DDT mixture, and the next from endrin. It is doubtful, though, if the 1.5% endrin treatment would be satisfactory against heavy infestations of the boll weevil.

1957 - McGarr, R. L. Insecticides for pink bollworm and boll weevil control in the Lower Rio Grande Valley in 1955 and 1956. J. Econ. Ent. 50(5):672-674.

TESTS IN 1955.--Series 1. Treatments of Guthion plus DDT and endrin plus DDT sprays noticeably reduced the boll weevil infestations and produced fair

increases in yield. Spider mites increased enough to require control measures in the endrin-DDT plots.

Series 2. High infestations of both pink bollworms and boll weevils developed in this experiment. Very good control of both insects was obtained from 5% Guthion applied as a dust at approximately weekly intervals. The increase in seed cotton yield was outstanding--2034 pounds.

TESTS IN 1956.--Series 1. This group consisted of a comparison of Guthion plus DDT and Phosdrin plus DDT applied as sprays. Guthion noticeably reduced the boll weevil populations, whereas Phosdrin failed to give any appreciable control. Increases in yield over the untreated plot ranged from 510 lbs. (Phosdrin-DDT) to 1,030 lbs. (Guthion-DDT).

Series 2. This series was composed of only 1 spray test with 3 0.5-acre replicates of Guthion plus DDT and endrin plus DDT. The last 2 applications were made with 2% endrin dust and 3% Guthion dust, since the plots were too wet for operation of the sprayer.

Both the endrin and the Guthion gave effective control of the boll weevil. The best yield increase was obtained from the endrin-DDT (976 lbs. seed cotton per acre), as compared to 643 lbs. from the Guthion-DDT plots.

Series 3. This dust series consisted of 2 tests with 3 0.25-acre replicates of Guthion plus DDT and Guthion alone. Both the pink bollworm and the boll weevil were important in this series, especially in one of the tests. Three percent Guthion was effective against the boll weevil. Yield increases were good for each treatment--1,284 lbs. and 1,270 lbs. respectively.

Series 4. This was a dust series and consisted of 1 test with 3 0.25-acre replications of endrin plus sulfur, and calcium arsenate. An unusually heavy boll weevil infestation occurred during the entire poisoning program. Satisfactory control of the populations was obtained from the endrin plus sulfur, whereas the results from the calcium arsenate were not as good as expected. Yield increases were 1,860 lbs. from the endrin plus sulfur applications and 1,310 lbs. from the calcium arsenate ones.

1957 - Merkl, M. E., and R. E. Furr. Experiments on control of early season cotton insects with systemic insecticides. Assoc. So. Agr. Workers Proc. 54:145.

Results of field tests for control of early-season cotton insects with systemics. Thimet and Bayer 19639 were used in these experiments at dosages of 0.1 to 3.0 pounds per acre. Treatments were applied to cotton seeds or directly to the furrow in which the seeds were planted.

There was no indication of control of overwintered boll weevils by these treatments.

1957 - Parencia, C. R., Jr., J. W. Davis, and C. B. Cowan. Control of early-season cotton insects with systemic insecticides employed as seed treatments. J. Econ. Ent. 50(1):31-36.

The effectiveness of Am. Cyanamid 12009, 12008, and 3911 employed as seed treatments against thrips (Frankliniella sp.), cotton aphid (Aphis gossypii Glov.), serpentine leaf miner (Liriomyza pusilla (Meig.)), cotton fleahopper (Psallus seriatus (Reut.)), and the overwintered boll weevil (Anthonomus grandis Boh.), was evaluated in field experiments conducted near Waco, Tex., in 1954 and 1955.

In 1954, plant emergence was reduced by 39% by the 12009 and 13% by the 12008 treatments. The planting rate was less than desired, and the compounds were applied at slightly more than 1/2 pound per acre.

In most of the 1955 experiments, the treated seed was planted under good germinating conditions and 1 lb. per acre dosages of 3911 and 12008 did not adversely affect plant emergence. Emergence was reduced in a planting of 3911-treated seed following a heavy rain on the day after planting.

When adult cotton fleahoppers and overwintered boll weevils were installed at weekly intervals after plant emergence on caged plants in the 1 lb. 3911 seed treatment, there was a progressive loss in effectiveness with plant growth. Field

records indicated control was obtained 4 weeks after plant emergence but effectiveness did not persist long enough for control to be comparable with that obtained with a conventional early-season insecticidal treatment.

1957 - Parencia, C. R., Jr., J. W. Davis, and C. B. Cowan, Jr. Further field tests with systemic insecticides employed as seed treatments. J. Econ. Ent. 50(5):614-617.
The control of overwintering boll weevil with systemics was considered as poor. Toxaphene spray treatments were more effective than the seed treatments.

1957 - Pfrimmer, T. R. Insecticide tests against cotton insects as Tallulah, Louisiana, in 1956. Assoc. So. Agr. Workers Proc. 54:145.
Guthion (Bayer 17147) was the outstanding material used against the boll weevil. The chlorinated hydrocarbons produced little or no control of the boll weevil.

1957 - Robertson, R. L., Effect of seed and soil treatment with systemic insecticides and on cotton insects and on stand and yield of cotton. Assoc. So. Agr. Workers Proc. 54:147.
Boll weevil infestations were somewhat lower in plots receiving side dressing with systemics than on untreated plots. No increases in yield over untreated plots were obtained. There was, however, a reduction in yield from one thimet treatment due to the reduction in stand resulting from seed treatment.
Boll weevil and bollworms were controlled effectively with Guthion-DDT sprays. Six applications of Guthion-DDT containing twice the regular concentration of Guthion and DDT, when applied at 8-day intervals, controlled boll weevils and bollworms about as effectively as 12 sprayings at regular dosages of these materials at 4-day intervals.

1957 - Robertson, R. L., and F. S. Arant. Effect of different methods and intervals of application of insecticides on cotton insect control. Assoc. So. Agr. Workers Proc. 54:145-146.
Toxaphene, endrin, and Guthion-DDT appeared to be about as effective against boll weevil when applied as dusts at 8-day intervals at the average rate of 30 lbs. per acre as when applied at 4-day intervals at 15 lbs. per acre. Dieldrin-DDT mixtures were not effective at the longer intervals. Two applications of heptachlor or Guthion granules (1-1/2 lbs. of technical) followed by 4 conventional dustings with heptachlor-DDT and Guthion-DDT, respectively, were about as effective as 13 conventional applications of toxaphene. There was no indication of boll weevil resistance to the chlorinated hydrocarbon insecticides.
A heavy cotton aphid infestation developed in plots where calcium arsenate was used and spread over the experimental area, with the exception of plots treated with endrin and Guthion-DDT. Aphids were effectively suppressed in plots treated with these materials.

1957 - Roussel, J. S., J. Brazzel, R. C. Gaines, and R. Young. Effect of lipid content of boll weevils on insecticidal action of endrin and guthion. Assoc. So. Agr. Workers Proc. 54:144.
Topical application of endrin or Guthion was made to boll weevils fed squares, blooms, and bolls for varying periods of time. The lipid content of boll weevils was determined. A discussion of the insecticidal action of endrin and Guthion on boll weevils fed these different foods for varying periods of time is given.

1957 - Young, R., and J. S. Roussel. The effect of temperature on the efficiency of insecticides applied topically to the boll weevil. Assoc. So. Agr. Workers Proc. 54:144.
Field-collected boll weevils were treated topically with toxaphene, endrin, malathion, and combinations, and were held at post-treatment temperatures of 60°, 80°, and 90° F.

1958 - Beckham, C. M., and L. W. Morgan. Evaluation of systemic insecticides for control of cotton insects. Ga. Agr. Expt. Sta., Mimeo Ser., n. s. 54. April.

Field tests were conducted to obtain information on the effects of different rates of thimet and Di-syston applied as seed treatments and as granulated formulations in the furrow on plant emergence. There was no adverse effect on germination. Results of square counts showed that thimet and Di-syston were not effective in controlling the boll weevil.

1958 - Bottger, G. T., A. J. Chapman, Rex L. McGarr, and C. A. Richmond. Laboratory and field tests with sevin against cotton insects. J. Econ. Ent. 51(2):236-239.

In laboratory tests at Brownsville, Tex., Sevin (1-naphthyl-N-methyl carbamate) applied as a spray to potted cotton plants was effective against the boll weevil (Anthonomus grandis Boh.), the pink bollworm (Pectinophora gossypiella Saund.), the bollworm (Heliothis zea Boddie), the cabbage looper (Trichoplusia ni Hbn.), and the cotton aphid (Aphis gossypii Glov.). On field plots in the Lower Rio Grande Valley, dusts containing 1.5 to 2.5 lbs. of Sevin per acre applied at 4- to 7-day intervals gave control of the pink bollworm and the boll weevil comparable with that obtained with standard insecticides.

1958 - Furr, R. E., and E. P. Lloyd. Preliminary field cage studies on the residual toxicity of methyl parathion, Guthion and malathion to adult boll weevils. Assoc. So. Agr. Workers Proc., 55:122.

Guthion 0.25 lb./ac, methyl parathion 0.25 lb./ac, and malathion 0.5 lb./ac were applied as emulsions to field plots at the rate of 3.7 gallons of spray per acre. Fifty adult boll weevils were confined to each treated plot immediately after treatment and at 2-hour intervals thereafter for 12 hours. Mortality counts were made each hour for 10 hours. Guthion gave highly effective kill in 24 hours, even when the weevils were caged 12 hours after treatment. Methyl parathion was not effective (less than 75% kill) 4 hours after treatment. Malathion was not effective 8 hours after treatment.

In a second experiment, Guthion 0.5 lb./ac, methyl parathion 0.5 lb./ac, and malathion 2.0 lbs./ac were used. Guthion was highly effective in this experiment. Methyl parathion was effective for 6 hours, and malathion was effective for 24 hours, even when the weevils were caged 24 hours after treatment.

1958 - Hightower, B. G., and D. F. Martin. Effects of certain climatic factors on the toxicities of several organic phosphorus insecticides. J. Econ. Ent. 51(5):669-671.

The independent effects of wind, simulated rain, and temperature variations on the residual toxicities of several organic phosphorus pesticides were evaluated in laboratory tests. The boll weevil and the tumid spider mite (Tetranychus tumidus Banks) were used as test animals.

Temperature and humidity variations encountered under prevailing greenhouse conditions were important factors contributing to the loss of residual toxicity in these compounds. Phosdrin lost most of its residual toxicity to boll weevils and spider mites when exposed to temperatures ranging from 70°F. to 104°F., and relative humidity ranging from 40% to 86%. Guthion spray was superior to endrin or dieldrin sprays when subjected to temperatures above 100°F. before release of boll weevils on the plants.

Guthion dust was more effective than toxaphene or dieldrin dusts under prerelease windy conditions at relatively high temperatures. Simulated rain appreciably reduced the residual toxicities of Guthion, methyl parathion, and malathion sprays.

1958 - Hopkins, A. R., R. E. Fye, and R. L. Walker. Field tests with thimet and Bayer 19639 for cotton-insect control. J. Econ. Ent. 51(1):100-102.

Experiments were conducted to determine the effectiveness of seed treatments of thimet and Bayer 19639, in-furrow applications of granular thimet made at the time of planting and side dressing applications of granular thimet for the control of cotton insects, and also, to determine the effect of the materials on the cotton plant itself. The treatments tested afforded virtually no control of the boll

weevil but gave good to excellent aphid control throughout the complete growing period of the plant. There was no evidence that thimet was taken up or translocated more readily in soils with a lower level of phosphorus. Seed treatments of thimet and Bayer 19639 adversely affected stands. In-furrow treatments of thimet did not affect stands. None of the treatments affected plant height. Only one treatment, the thimet 2-pound in-furrow treatment, adversely affected fruiting. The treatments had no adverse effect on grade and staple or on the germination of seed produced with these treatments. Likewise, such properties as fiber strength, maturity, fineness, boll size, seed index, lint index, and percent of lint were not affected by any of the treatments.

1958 - Lloyd, E. P., R. E. Furr, and M. E. Merkl. Seasonal variation in susceptibility of boll weevils to insecticides. Assoc. So. Agr. Workers Proc. 55:121.

Results of topical application tests in the fall of 1956 and the spring of 1957 indicated seasonal differences in susceptibility of the boll weevil to insecticides. LD_{50} values obtained with aldrin, BHC, endrin, toxaphene, heptachlor, Thiodan, malathion, methyl parathion, Guthion, and Phosdrin for weevils from the hill and delta sections of Mississippi are presented.

1958 - Mistric, W. J., Jr., and R. T. Gast. Susceptibility of the boll weevil to toxaphene in North Carolina. J. Econ. Ent. 51(5):719-721.

Results of laboratory tests showed that susceptibility of the boll weevil to toxaphene was related to the previous field usage of chlorinated hydrocarbon insecticides for weevil control. Weevils from fields subjected to intensive insecticidal treatment were much less susceptible than those from nearby fields where little insecticide had been used. The greatest difference in the susceptibility of weevil populations from different counties was 200-fold, while the greatest difference within a county was 75-fold.

A field test, conducted on the weevil population least susceptible to toxaphene, showed that Guthion, malathion, methyl parathion, and calcium arsenate were superior to toxaphene in weevil control and yield of cotton. However, complete failure to toxaphene to control this weevil population was not experienced.

1958 - Pfrimmer, T. R. Insecticide tests against the boll weevil and the bollworm at Tallulah, La., in 1956. J. Econ. Ent. 51(1):41-43.

In small-plot experiments with several insecticides applied as dusts and sprays for the control of the boll weevil and the bollworm (Heliothis zea Boddie) conducted at Tallulah, La. during 1956, Guthion gave excellent boll weevil control in all tests at dosages from 0.25 to 0.6 lb. per acre. Calcium arsenate dust, methyl parathion at 0.5 and 0.67 lb., EPN at 0.5 and 0.8 lb., and malathion at 2.05 and 3.81 lbs. per acre were slightly less effective. Methyl parathion at 0.40 lb., Dipterex and Dow ET-15 at 0.5 lb., and calcium arsenate spray at 12.9 lbs. per acre gave only fair control. DDT was included in most of these treatments. In one experiment, endrin spray at 0.3 lb. gave fair control, but endrin dust at 0.37 lb. per acre was ineffective. In other experiments endrin, Thiodan, and heptachlor were ineffective at the dosages used.

1958 - Pfrimmer, T. R., and M. E. Merkl. Dosage-interval tests with phosphate insecticides on cotton insects at Stoneville, Mississippi. Assoc. So. Agr. Workers Proc. 55:121.

During the cotton-growing season of 1957, three small plot field tests were conducted against cotton insects. Various dosages (lb./ac.) of Guthion (0.25-0.75), methyl parathion (0.25-0.50), and malathion (0.5-2.0) are compared at different intervals of treatment ranging from 3 to 10 days. Results against the boll weevil, bollworm, aphids, and spider mites are given.

1958 - Pfrimmer, T. R., E. P. Lloyd, and M. E. Merkl. Field tests with new insecticides against cotton insects at Stoneville, Mississippi. Assoc. So. Agr. Workers Proc. 55:121.

Several new insecticides and insecticide combinations were tested in small-plot field experiments against cotton insects during 1957. These materials

included Sevin, Korlan, Monsanto CP-7769, Thiodan, Phosdrin, and Hercules 3895. Results on the effects of these materials against boll weevil, bollworms, aphids, and spider mites are given.

1958 - Walker, J. K., Jr. Control of boll weevils resistant to chlorinated hydrocarbon insecticides. Tex. Agr. Expt. Sta. Prog. Rpt. 2009. Feb. 13.

Evaluations of insecticides were made in two areas in the Brazos River Valley--one with weevils resistant to chlorinated hydrocarbon insecticides and one with no resistance.

In the resistant area, phosphorus compounds were more effective than chlorinated hydrocarbons. In the nonresistant area, each type of insecticide was equally effective.

1958 - Walker, R. L., Jr., A. R. Hopkins, and R. E. Fye. Effectiveness of several insecticides against the boll weevil, bollworm, and cotton leafworm. J. Econ. Ent. 51(6):783-786.

In small-plot experiments at Florence, S. C., against the boll weevil, Guthion-DDT, Thiodan, methyl parathion-DDT, EPN-DDT, and endrin dusts gave comparable control and yields. Sprays and dusts of Guthion and endrin and a spray of Dipterex were equally effective. Guthion-DDT spray gave significantly better control and yield than toxaphene and heptachlor-DDT sprays. Sprays of Guthion-DDT, Dipterex-DDT, methyl parathion-DDT, EPN-DDT, and endrin gave comparable control and yields. Dusts of Sevin, malathion, Guthion-DDT, and endrin gave comparable control. Sprays and dusts of Guthion, malathion, and endrin were equally effective. In a spray, malathion was more effective at 2 lbs. per acre than at 1 lb. Malathion plus endrin was more effective than endrin alone. Sprays of Sevin, Thiodan, endrin, toxaphene with and without methyl parathion, and methyl parathion gave comparable control.

In field-cage experiments against the boll weevil, malathion and methyl parathion gave consistently high 24-hour mortalities. Combinations of malathion with endrin or toxaphene were usually more effective than endrin or toxaphene alone. Guthion was more effective than toxaphene and BHC. Thiodan was less effective than endrin. Sevin at 2 lbs. per acre gave high 48-hour kills. Monsanto CP-7769 and Chipman R-6199 were comparatively ineffective. Malathion was residually more effective than endrin, methyl parathion, or Thiodan.

1958 - Wene, George P., and Michael Schuster. Boll weevil control with heptachlor granules. J. Econ. Ent. 51(1):114.

The results of this experiment indicate that applications of 2.5% heptachlor granules to early localized boll weevil infestations will tend to prevent injury early in the cotton season.

1959 - Brazzel, J. R., B. G. Hightower, and T. L. Pate. A new method for the control of boll weevils. Tex. Agr. Expt. Sta. Prog. Rpt. 2110. Oct. 9.

A late season chemical and cultural control program in 1959 showed promise in reducing the overwintering population of boll weevils. This reduction appears to be great enough to delay the start of boll weevil control programs the following year to effect substantial savings in insecticide costs.

The program consists of chemical treatment just prior to and during the harvest period to prevent the weevil from going into diapause, the physiological condition in which they survive the winter. These insecticide treatments are followed by stalk destruction if harvest is completed before frost kills the cotton.

Results indicate that this practice may be an effective eradication measure.

1959 - Cowan, C. B., Jr., C. R. Parencia, and J. W. Davis. Field experiments for control of late-season infestations of several cotton insects. J. Econ. Ent. 52(5):975-977.

Sevin (1-naphthyl-N-methyl carbamate) applied at 1.0 and 1.6 lbs. per acre in dusts and at 1.5 lbs. per acre in a spray gave effective control of the boll

weevil and the bollworm (Heliothis zea (Boddie)) in field-plot experiments conducted in 1958. Sprays containing calcium arsenate at 7 lbs., Monsanto CP-7769 (hexaethyl (ethylthiomethylidine) triphosphonate) at 0.5 pound, or dicapthon at 1.0 lb. per acre were as effective in boll weevil control as dieldrin at 0.38 lb. or Guthion (O,O-dimethyl S-(4-oxo-3H-1,2,3-benzotriazine-3-methyl) phosphorodithioate) at 0.25 lb. per acre.

1959 - Enkerlin S., Dieter. Different concentrations of Thiodan for the control of cotton insects. J. Econ. Ent. 52(6):1068-1069.

Three small-plot experiments were conducted in Mexico to evaluate the effectiveness of Thiodan (6,7,8,9,10,10-hexachloro, 1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepin-3-oxide) in the control of cotton fleahopper (Psallus seriatus (Reut.)), bollworm (Heliothis zea (Boddie)), cabbage looper (Trichloplusia ni (Hbn.)), and boll weevil (Anthonomus grandis Boh.). Dust formulations were used for the first and third experiments, and sprays for the second. Thiodan 3% and 4% dust as well as sprays containing 0.52 and 0.32 kilograms of technical thiodan per hectare gave good results compared with other commonly used insecticides.

1959 - Mistric, W. J., Jr., and E. J. Spyhalski. Response of cotton and cotton pests to thimet seed-treatment. J. Econ. Ent. 52(5):807-811.

Coker 100W cottonseed treated with Thimet (0,0-diethyl S-(ethylthio) methyl phosphorodithioate) was evaluated in replicated field tests at 4 widely separated locations in North Carolina during 1955-56. Thimet exhibited pronounced effects both upon the cotton plant and upon the pests which attack cotton. Thimet seed-treatments were particularly effective in controlling thrips, Frankliniella fusca (Hinds), F. exigua (Hood), F. tritici (Fitch), Thrips tabaci (Lind.), and the cotton aphid, Aphis gossypii (Glov.), until the time of squaring. This material afforded seasonal protection from spider mites, Tetranychus cinnabarinus (Bois.) and T. telarius (L.). Thimet was partially effective in reducing boll weevil infestations throughout the season, but the use of this material favored the development of bollworm, Heliothis zea (Boddie), and tobacco budworm, H. virescens (F.), infestations. Delayed fruiting of cotton appeared to be the most detrimental characteristic associated with the use of Thimet. However, certain adverse effects upon the germination, emergence, and vegetative growth of cotton were also noted.

1959 - Parencia, C. R., Jr. Comparative yields of cotton in treated and untreated plots in insect-control experiments in central Texas, 1939-1958. J. Econ. Ent. 52(4):757-758.

Field experiments for the control of cotton insects have been conducted each year since 1939, when the U. S. D. A. Cotton Insects Laboratory was established at Waco. The primary objective has been to evaluate insecticides and methods of application against the various pests. Yields from fields or plots treated with candidate insecticides have been compared with those receiving a standard insecticide and with those receiving no treatment. The insects of primary importance in most years were the boll weevil (Anthonomus grandis Boh.) and the bollworm (Heliothis zea (Boddie)). The average increase in yield from treated over untreated plots was 309 pounds of seed cotton per acre, or 41.8%.

1959 - Walker, J. K., Jr., and R. L. Hanna. Field plot insecticide tests for the control of the boll weevil and the bollworm in 1958. Tex. Agr. Expt. Sta. Prog. Rpt. 2069. Jan. 26.

Five field plot tests designed to give information on the effectiveness of several insecticides were conducted in the Brazos River Valley. Chlorinated hydrocarbon materials as a group appeared to be less effective for the control of the boll weevil than most other insecticides tested. Sevin gave excellent boll weevil control. Other materials showing promise were dicapthon and Trithion.

1960 - Bass, Max H., and James W. Rawson. Some effects of age, preimaginal habitat, and adult food on susceptibility of boll weevil to certain insecticides. J. Econ. Ent. 53(4):534-536.

Experiments were conducted to determine the toxicity of Guthion (0,0-dimethyl S-(4-oxo-1,2,3-benzotriazin-3-(4H)-ylmethyl) phosphorodithioate), BHC, and toxaphene to the boll weevil under certain conditions of preimaginal habitat, adult food source, and weevil age. There was a 48- and 61-fold difference in the LD-50 of BHC and toxaphene, respectively, between the easiest to kill group (square-reared, bloom-fed, 2-day-old) and the hardest to kill group of weevils (boll-reared, boll-fed, 9-day-old). The LD-50 values were relatively constant in all tests using Guthion.

The susceptibility of boll weevils to BHC and toxaphene was influenced to a greater extent by the adult food source than the age of the weevil or its preimaginal habitat.

Based on LD-50 values, the order of susceptibility of the boll weevil to BHC and toxaphene was: boll-reared $<$ square-reared, square-fed $<$ bloom-fed, boll-fed $<$ square-fed, and 9-day-old $<$ 2-day-old weevils.

1960 - Boyd, N. R., Jr., and B. W. Arthur. Biological degradation of 0,0-diethyl 0-naphthalimido phosphorothioate (Bayer 22408). J. Econ. Ent. 53(5):848-853.

P^{32}-labeled Bayer 22408 (0,0-diethyl 0-naphthalimido phosphorothioate) was converted to the oxygen analog, 0-ethyl phosphoric, 0,0-diethyl phosphoric, 0,0-diethyl phosphorothioic acids and at least 3 other metabolites by rats, several species of insects (including the boll weevil), and cotton plants. Differences in the degradation of Bayer 22408 by the 3 biological systems were not the result of the number of metabolites but of the amount of each metabolite formed. Bayer 22408 was stable in insects and most of the absorbed material was recovered as administered; the oxygen analog was formed to a limited extent. Rats degraded Bayer 22408 rapidly to water-soluble phosphoric acids, which were eliminated primarily in the urine. Some Bayer 22408 escaped degradation and was eliminated intact in the feces. Bayer 22408 was not effective as an animal systemic against several ectoparasites feeding on treated rabbits. Bayer 22408 was quite stable on the foliage of cotton plants but was not translocated to untreated portions of plants.

1960 - Brazzel, J. R., and D. A. Lindquist. The effectiveness of chlorinated hydrocarbon insecticide mixtures for control of resistant and susceptible boll weevils. J. Econ. Ent. 53(4):551-554.

The toxicity of toxaphene and DDT alone and combined in various proportions on laboratory-reared toxaphene resistant and susceptible strains of the boll weevil was studied. Toxaphene-DDT mixtures exhibited synergistic effects on resistant weevils, but only additive effects for susceptible ones. A mixture of 4 parts toxaphene and 1 part DDT was the most effective combination tested against resistant weevils. A dosage of 5 to 15 micrograms of toxaphene in combination with DDT was required to produce 50% mortality of resistant weevils, regardless of the amount of DDT in the combination.

No evidence of synergism was found using mixtures of toxaphene with methoxychlor or DDE. A mixture of Strobane-DDT was slightly less effective than toxaphene-DDT, but the synergistic effect was evident with resistant weevils. Strobane is a mixture of chlorinated terphenes with about 66% of chlorine.

No evidence was found of seasonal tolerance in field-collected boll weevils to a 2-1 mixture of toxaphene-DDT.

1960 - Burkhalter, Glenn F., and F. S. Arant. Boll weevil susceptibility to Toxaphene, Endrin, and Guthion in five Alabama localities. J. Econ. Ent. 53(2):311-313.

Laboratory experiments were conducted in 1956 and 1957 to determine the susceptibility of the boll weevil, Anthonomus grandis Boh., to toxaphene, endrin, and Guthion (0,-0-dimethyl S-(4-oxo-1,2,3,-benzotriazin-3-(4H)-ylmethyl) phosphorodithioate) in five Alabama localities. The technical insecticides were dissolved in acetone and applied topically to 2-day-old weevils reared from

cotton squares. Mortalities were determined at the end of 72 hours. Approximately 25,000 weevils were used in the experiments. During 1957, LD-50 values varied among populations from different localities as follows: for toxaphene, from 12.5 to 61.8 μg. per gm. of boll weevil; for endrin, from 0.8 to 3.5 μg. per gm; for Guthion, from 0.9 to 2.3 μg. per gm. There was no evidence of acute resistance of the boll weevil from any of 5 localities to any insecticide tested. Mortality variations between times of year and between the 2 years were as great as among locality groups.

1960 - Cowan, C. B., Jr., J. W. Davis, and C. R. Parencia, Jr. Field experiments against several late-season cotton insects in 1959. J. Econ. Ent. 53(5):747-749.

Strobane-DDT was as effective against the boll weevil and the bollworm (Heliothis zea (Boddie)) as toxaphene-DDT Guthion-DDT gave better control of the boll weevil than Shell SD-3562 and Shell SD-4402, but it was no better than Shell SD-5539-DDT. Sevin gave better boll weevil control than Geigy G-30494-DDT, but it was not better than Bayer 25141. There was no difference in boll weevil and bollworm control obtained with Sevin applied in a dust or in a wettable powder formulation. Shell SD-4402 was effective against bollworms but Shell SD-3562 was ineffective. Bayer 25141 at dosages used was less effective than standard materials. There was no difference in control of the cotton aphid Aphis gossypii Glov.) and the desert spider mite (Tetranychus desertorum Banks) with demeton, ethion, Trithion, Bayer 25141, Shell SD-3562 and Geigy G-30494. Sevin, Shell SD-3562, and Shell SD-4402 were as effective as methyl parathion against the cotton leafworm (Alabama argillacea (Hbn.)). Bacillus thuringiensis showed some promise in the control of this insect.

1960 - Hightower, B. G., and J. C. Gaines. Residual toxicities of insecticides to cotton insects. Tex. Agr. Expt. Sta. B. 951. Mar.

Results of experiments conducted to determine the effect of natural or simulated climatic conditions on the residual toxicities of several chlorinated hydrocarbon and organo-phosphorus insecticides to several species of cotton insect pests. In tests with the boll weevil, endrin and Sevin appeared to have similar residual properties. Based on residual properties alone, toxaphene and dieldrin ranked with endrin and Sevin, but the initial toxicities of endrin and dieldrin were greater than toxaphene. Mortality rates for these insecticides were reduced 20% to 30% after exposure to simulated wind and rain. Residual properties of aldrin and BHC were inferior; heptachlor was erratic. Guthion exhibited the best residual properties against the boll weevil of the organo-phosphorus materials.

1960 - Parencia, C. R., Jr., and C. B. Cowan, Jr. Increased tolerance of the boll weevil and cotton Fleahopper to some chlorinated hydrocarbon insecticides in central Texas in 1958. J. Econ. Ent. 53(1):52-56.

The boll weevil and cotton fleahopper (Psallus seriatus (Reut.)) showed increased tolerance to several of the chlorinated hydrocarbon insecticides in central Texas in 1958. Topical-application studies on weevils reared from squares collected from one field in July indicated increased tolerance to toxaphene and a high tolerance to dieldrin. In field experiments much better control was obtained with Sevin (1-naphthyl N-methyl carbamate) and such organic-phosphorus compounds as Guthion (0,0-dimethyl S-(4-oxo-3H-1,2,3-benzotriazine-3-methyl) phosphorodithioate) and malathion than with toxaphene and dieldrin. Dosages of toxaphene, dieldrin, and heptachlor, 2 and 3 times those effective in previous years, failed to control the cotton fleahopper. Sevin, Guthion, malathion, toxaphene plus DDT, dieldrin plus DDT, and DDT alone were effective, but DDT has not been used against the cotton fleahopper for 10 years in the area.

1960 - Parencia, C. R., Jr., C. B. Cowan, Jr., and J. W. Davis. Control of several early-season cotton pests with insecticides. J. Econ. Ent. 53(6):1051-1054.

A mixture of toxaphene plus DDT and Guthion (0,0-dimethyl S-(4-oxo-1,2,3-benzotriazin-3-(4H)-ylmethyl) phosphorodithioate) or methyl parathion

gave much better control of the boll weevil and the cotton fleahopper (Psallus seriatus (Reut.)) than dieldrin or toxaphene. Toxaphene was more effective than Strobane (mixture of chlorinated terpenes with about 66% of chlorine) against thrips (Frankliniella sp.), but both materials gave poor control of cotton fleahoppers and boll weevils. In mixtures with DDT the materials were equally effective against these pests. Sevin (1-naphthyl methylcarbamate) in a wettable-powder formulation was effective against thrips, cotton fleahoppers, and boll weevils, but rains occurring a short time after application reduced its effectiveness. Shell SD 4402 (1,3,4,5,6,7,8,8-octachloro-3a,7,7a-tetrahydro-4,7-methanophthalan), Shell SD 3562 (dimethyl 1-(dimethylcarbamoyl)-1-propen-2-yl phosphate), Bayer 25141 (0,0-diethyl 0-(p-methylsulfinyl) phenyl phosphorothioate), and dimethoate were as effective as dieldrin in thrips control.

1960 - Pfrimmer, T. R., E. P. Lloyd, M. E. Merkl, and R. E. Furr. Field experiments with several insecticidal sprays against the boll weevil and bollworm. J. Econ. Ent. 53(5):711-714.

In experiments at Stoneville, Miss., in 1957 and 1958, a Guthion-DDT mixture gave outstanding control of the boll weevil. Sevin (1-naphthyl methyl-carbamate), toxaphene-malathion, dicapthon, Bayer 29493 (0,0-dimethyl 0-(4-methylthio-m-tolyl) phosphorothioate), and mixtures of Monsanto CP 7769 (hexaethyl (ethylthiomethylidyne) triphosphonate), methyl parathion, toxaphene, or malathion with DDT gave generally satisfactory control, but Thiodan (6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepin-3-oxide), ronnel-DDT, toxaphene, and endrin were not effective. The mixture of DDT with ronnel, Monsanto CP 7769, Guthion (0,0-dimethyl S-(4-oxo-1,2,3-benzotriazin-3-(4H)-ylmethyl) phosphorodithioate), methyl parathion, and malathion were effective in controlling the bollworm (Heliothis zea (Boddie)).

1960 - Tsao, Ching H., and G. T. Bottger. Laboratory studies on the effectiveness of Chipman R-6199 against some cotton pests. J. Econ. Ent. 53(1):103-106.

Chipman R-6199, the monohydrogen oxalate of 0,0-diethyl S-(2-diethylamino)-ethyl phosphorothioate, was tested against insects introduced on potted cotton plants held in the laboratory. At 5 mg. per plant it was effective against adults of the boll weevil, but the residual effect was short-lived.

1960 - Tsao, Ching H., and W. L. Lowry. Factors affecting the tolerance of boll weevils to calcium arsenates. J. Econ. Ent. 53(5):844-847.

Boll weevils emerged from cotton bolls were more tolerant to tricalcium arsenate than those emerged from squares. Their wet weight and fat content were also greater. When field-collected weevils were exposed to calcium arsenate in petri dishes, with or without cotton squares for food, the insects that died first had lower body weight and fat content than those that died later. Tricalcium arsenate and commercial calcium arsenate were found to kill weevils when ingestion of the poisons was made impossible, but their effectiveness was reduced by half. Weevils treated with calcium arsenates lost weight more rapidly under desiccation than untreated live or dead weevils. The mortality of treated insects decreased as the humidity increased, but that of untreated insects showed little difference. These results indicate that under field conditions, when the evaporation rate is higher than that in the laboratory, the desiccating action of calcium arsenates may be responsible for partial control of the insects.

1960 - Walker, J. K., Jr., and R. L. Hanna. Control of boll weevils resistant to chlorinated hydrocarbons. J. Econ. Ent. 53(2):228-231.

During 1956, 1957, and 1958, 15 replicated field-plot insecticide-comparison experiments were conducted in the Robertson-Burleson County area of south-central Texas, to determine the effectiveness of various insecticides for control of boll weevils resistant to chlorinated hydrocarbon insecticides. Guthion (0,0-dimethyl S-(4-oxo-3H-1,2,3-benzotriazine-3-methyl) phosphorodithioate), Sevin (1-naphthyl methylcarbamate), and calcium arsenate dust were most effective in controlling these weevil populations. Methyl parathion and malathion

effected good immediate kill of boll weevils but did not always prevent excessive weevil damage when applied at the customary 5-day interval. Chlorinated hydrocarbon materials varied considerably in relative effectiveness at the various locations but were generally the least effective of the insecticides used. All insecticides except Sevin were combined with DDT for bollworm control.

1960 - Walker, J. K., Jr., and R. L. Hanna. Development of populations of the boll weevil in cotton fields treated with various insecticides during 1959. Tex. Agr. Expt. Sta. Prog. Rpt. 2152. Aug. 30.

Seasonal records of boll weevil populations, cotton fruiting, and weevil damage were obtained on a number of small fields which were treated with various insecticides during 1959 in the same locality at College Station. Well-timed applications of 0.5 lb. per acre of methyl parathion and 0.25 lb. of methyl parathion plus 1.5 lbs. of toxaphene reduced overwintered populations to such a degree that boll weevils did not become a serious late-season problem. Sevin at 0.5 lb. was not enough to control the boll weevils, but 1.25 lbs. per acre was effective for late-season control. Kill of overwintered weevils with 2.0 lbs. of toxaphene-DDT (2-1) was poor, but full season control with this material prevented serious damage. Toxaphene and Strobane used without DDT were ineffective.

1960 - Walker, J. K., Jr., and R. L. Hanna. Companion of toxaphene and strobane as dusts, sprays, and sprays with DDT for boll weevil and bollworm control. Tex. Agr. Expt. Sta. Prog. Rpt. 2147. July 6.

A replicated small plot test did not reveal any differences in effectiveness between toxaphene and strobane. The spray combinations with DDT were much more effective for boll weevil than the 2 materials used alone. Yield differences were not significant and no important differences in quality of lint or seed, due to different levels of infestation, were shown.

CONTROL - CULTURAL

1896 - Howard, L. O. The Mexican cotton boll weevil. U. S. D. A., Bur. Ent. C. 14(2): 8, fig. 1-5.

While styled a revision of C. 6, this circular contains additional information relative to distribution, natural history, habits, and natural enemies and parasites, now worked out with substantial accuracy, incorporating the results of field studies by E. A. Schwarz, Mr. Townsend, and the author of the circular.

Under the head of remedies is the first suggestion of the great importance of the cultural method of control, and especially the early fall destruction of the cotton plants, together with the recommendation of early planting and clean cultivation. Trapping late beetles in fall and over-wintered beetles early in spring are advised, together with the destruction of volunteer plants, the region infested up to this time being fairly within the range of volunteer or seppa cotton.

1897 - Anderson, J. D. After the boll weevil. Texas Stockman & Farmer 17(9):4. Dec. 8.

Results of a meeting of farmers in Cuero, Tex. As a preventive against boll weevil loss, the burning of the cotton stalks and trash in fields was recommended. Certain "useless" proceedings were also recommended, such as use of light traps and poisoning with various substances.

1901 - Balestrier, L. de. Contra el picudo. El Progreso de Mexico, 8:481-482, May 22: 497-498, May 30:531-532. June 15:545-546. June 22.

Discusses traps, collection of squares, burying of squares, rates of development of weevils, early maturing cotton, occurrence of weevils in cotton seed, destruction of stalks by burning and grazing, spread of the weevil, difficulties in the application of cultural methods and their value are emphasized.

1901 - Mally, F. W. Colonizing the boll weevil. Farm & Ranch 20:3-4. Oct. 26.
Urges close grazing of cotton stalks in fall. When all stalks cannot be grazed down, the author recommends mowing all but a few rows which are left as a trap, those rows to be poisoned frequently or grazed down. Plans are given for a home-made stalk cutter.

1901 - Rangel, A. F. Cuarto informe acerca del picudo del algodon (Insanthonomus grandis I. C. Cu). Comn. Parasit. Agr. B. 1(7):245-261. Mexico.
Various experiments in weevil control. The report contains remarks on the necessity for growing a variety of cotton which will shed the infested squares, if the picking up of squares is to be of importance as a method of control. Experiments with gases are reported.

1901 - Rangel, A. F. Tercer informe acerca del picudo del algodon. Comn. Parasit. Agr. B. 1(6):197-206. Mexico.
Remarks on the collection of adult weevils from the plants, with description of an apparatus which was used with success in several experiments. The results of several experiments with the picking up of fallen infested squares. The habit of retaining infested fruit was noted on certain varieties and mentioned as a difficulty in destroying the weevil by picking up fallen squares. The deleterious effect of heat upon the weevil is mentioned, and observations upon the effect of sunlight on fallen infested squares. Recommends the use of varieties with sparse foliage and the wide spacing of plants; also laying of rows so as to admit the sun as much as possible.

1903 - Sanderson, E. D. The boll weevil. Texas Stockman & Farmer 22(14):4. Feb. 18.
Believes the burning of cotton stalks late in winter useless. Remarks on soil preparation and mentions various insects mistaken for the boll weevil.

1903 - Sanderson, E. D. How to combat the Mexican cotton-boll weevil in summer and fall. Tex. Sta. C. 4, 4 p.
The remedies for this insect, as mentioned by the author, consist in growing early maturing cotton and in destroying the beetles by grazing the cotton with cattle and pulling and burning the stalks which are unused. It is also recommended that the land be plowed deeply late in fall or early in winter.

1903 - Stubbs, W. C., R. E. Boulin, and H. A. Morgan. The Mexican cotton-boll weevil. La. Agr. Expt. Sta. C. 1:10, 3 fig. 1 map. Aug.
The boll weevil recently appeared on the experiment station grounds at Aududon Park, New Orleans, and drastic measures were taken for eradicating it. The crop of infested cotton was pulled up, dipped in kerosene, and burned; the soil was then saturated with kerosene and fired, after which it was flooded for several days. Cotton planters are urged to give close attention to their crop in order to detect the presence of the weevil at once. A brief account is given of the life history, habits, and appearance of the insect. Infected squares can be recognized readily by what is called "flaring," an opening out and spreading down from the bud of the involucre or shuck.

1904 - Anonymous. Perdidas de cosechas. Plan de cultive. El picudo del algodon. El Prog. de Mex. 11:714. Dec. 8.
Brief review of some of the work of the Comision de Parasitologia in putting into practice a cultural system of boll weevil control.

1904 - Anonymous. La. Agr. Expt. Sta. 16:6. Jan. 24.
The article reports the destruction of all varieties of cotton grown on the Louisiana Station during the summer of 1903. Some miscreant placed the Mexican boll weevil in one field and, to successfully exterminate it when found in August, it was deemed necessary to destroy every stalk of cotton on the Station. The cotton was pulled up by the roots, immersed in petroleum and burned; fallen bolls and squares were carefully picked up, saturated with petroleum, and also

burned. The soil was sprinkled with petroleum, carefully plowed, harrowed, rolled, oiled, reharrowed, rerolled, and rerolled. The land was then flooded for 5 consecutive days.

1904 - De la Barreda, L. The cotton-boll weevil. Comn. Parasit. Agr. C. 6:35. (Mex.)
An account is given of the habits, life history, and depredations of this pest, based in part upon publications of the U. S. D. A. Experiments were conducted by the Mexican Commission of Agricultural Parasitology for the purpose of determining successful means of combating the pest. It is recommended that attention be given the proper rotation of crops, careful selection of seed, flooding of the lands, and destruction of cotton plants in the fall.

1904 - Hunter, W. D. Information concerning the Mexican cotton-boll weevil. U. S. D. A. Farmers' B. 189:31, 8 fig.
As a result of the investigations thus far made in combating this insect, it is concluded that there is not even a remote probability that the boll weevil will ever be exterminated. The belief is expressed, however, that the insect can be sufficiently controlled to allow the production of profitable crops by practicing a number of preventive measures, such as early planting, use of seed of early varieties, thorough cultivation of the fields, planting rows far apart, destroying all the cotton stalks in the fields when the weevils become so numerous that all fruit is being punctured, and more extensive use of fertilizer.

1904 - Hunter, W. D. The most important step in the cultural system of controlling the boll weevil. U. S. D. A., Bur. Ent. C. 56:7.
Promotion of early crops of cotton for the prevention of boll weevil injury has been actively carried on by the Department. The matter of obtaining an early crop, however, is considered secondary in importance to the destruction of cotton plants in the field during the fall.
The author mentions that fall destruction of cotton plants prevents the development of many weevils which would otherwise become adult within a few weeks of the time of hibernation and also destroys a great majority of the weevils which have already become adult. The only weevils which survive the winter are those which become adult late in the season. The clearing of the cotton field in the fall permits the practice of fall plowing.

1904 - Sanderson, E. D. The cotton boll weevil in Texas. Soc. Prom. Agr. Sci. Proc. 25:157-170, 6 fig.
Contains a review of the work done on this insect, a statement of the methods of control recommended, and the changes made in these recommendations as the investigations proceeded. Attention is called to the fact that spraying has been generally abandoned as a remedy and that handpicking is meeting with little favor.

1905 - Hunter, W. D. The control of the boll weevil, including results of recent investigations. U. S. D. A., Farmers' B. 216:32, 5 fig.
This bulletin was prepared to replace Farmer's B. 189. It contains a restatement of the previous recommendations of the Bur. of Ent. regarding the means of controlling the boll weevil, together with an account of more recent work which has substantiated those recommendations.

1906 - Newell, W. The remedy for the boll weevil. La. Crop Pest Comn. C. 3:20, 5 fig.
Maps show the gradual advance of the boll weevil into La. with reference to the effects of cold rainy winters upon the pest. It is believed, however, that the boll weevil will be able to winter successfully in the cotton regions of La. Cultural methods are considered the only efficient remedy for controlling the boll weevil. These consist of early planting, the use of varieties which mature quickly, the application of fertilizers, thorough cultivation, and destruction of cotton plants in the fall, as well as other material in which the beetles may hibernate.

1907 - Flynn, C. W., Jr. Experiments in the late planting of cotton to avoid boll weevil damage during 1906. La. Agr. Expt. Sta. B. 92:8.

Experiments were conducted to determine whether general late planting in regions infested by the boll weevil could reduce the damage done by that insect.

One experiment was conducted in Vernon Parish in a field of $2\frac{1}{2}$ acres surrounded by forest and about 2.5 miles from any other cotton field being planted on June 6. On June 14, when the cotton was up to a stand, no boll weevils were observed, but on July 21, when the field had just commenced to square, 10.4% of the squares were found infested, and on August 15, 63.6%. An inspection of some of the nearest fields on July 21 showed that from 20.4% to 67.8% of the squares were infested with the boll weevil, and a later inspection showed 92.5% to 99.2% of the bolls infested. The experiment field, which in previous seasons produced 1,200 lbs. of seed cotton per acre without fertilizer, in 1906 with late planting, produced only 266 lbs, although well fertilized and well cultivated.

A second experiment at Merryville gave similar results, and the conclusion is drawn that late planting will not serve to solve the boll weevil problem.

1907 - Flynn, C. W., Jr. The boll weevil. La. Crop Pest Comn. C. 11:19, 2 fig.

A number of cultural experiments were carried out in different sections of the cotton belt, during which it appeared that Triumph cotton is the best variety for use in sections infested with boll weevil. Northern-grown seed, in order to retain its early maturing qualities, must be renewed from its northern sources at least every other year. The results obtained from these experiments confirm previous work along this line, and the author, therefore, recommends thorough preparation of the soil, early planting, the use of early varieties of cotton, abundant fertilizers, thorough cultivation of the crop, and destruction of cotton plants in the fall.

1907 - Herrick, G. W. The boll weevil. Miss. Agr. Exp. Sta. C., 7 p., Sept.

A brief and concise statement of the boll weevil situation. Methods of control are discussed. These include the fall destruction of cotton stalks and other cultural methods.

1907 - Hunter, W. D. The most important step in the control of the boll weevil. U. S. D. A., Bur. Ent. C. 95, 8 p. Oct. 3. Rev. ed. Sept. 21, 1908. French and English Ed.

A revision of Bur. Ent. C. No. 56, with additional data obtained from recent experiments. Following an introductory statement, results of a large practical test of the efficiency of the fall destruction of cotton stalks are presented. Reasons for the destruction of stalks in the fall are given; also a brief summary of the data obtained from a large series of hibernation experiments upon which these reasons are based.

1907 - Newell, W. Fighting the boll weevil by picking up the infested squares. La. Crop Pest Comn. C. 15, p. 4.

In average seasons when it is possible to produce an early crop of cotton the author does not recommend the additional expense necessary in picking up and destroying infested squares. It was impossible to secure an early crop during the present season and the author, therefore, suggested as a means of preventing the undue ravages of the boll weevil that fallen squares either be destroyed or confined in wire-cloth cages to allow the parasitic insects to escape.

1908 - Hinds, W. E. The first and last essential step in combating the boll weevil. J. Econ. Ent. 1(4):233-243.

The destruction of stalks by some effective method as early as possible before the normal time for weevils to enter hibernation constitutes the most effective method now known of reducing the severity of the weevil attack upon the following crop. The author considers that this procedure deserves general recognition and adaption as the last step in the treatment of each season's crop and also as the first step in the production of a crop with the minimum weevil injury during the following season.

1908 - Hunter, W. D. Getting rid of the boll weevil. Farm & Ranch 27(51):3 Dec. 19.
Contains a brief statement regarding boll weevil conditions in Texas. Injury during 1908 was less than during preceding years; reasons for scarcity are assigned and principal methods of control outlined.

1908 - Hunter, W. D. Regarding late planting to avoid damage by the boll weevil. Miss. Agr. Expt. Sta. Farmers' Inst. B. 120:17-24. Dec.
A review of the history of the late-planting theory as a means of boll weevil control and a collection of data, based mainly on experiments of the Bureau of Entomology, which show the fallacy of this idea.

1908 - Hutchinson, W. L. Cotton culture in Mississippi in areas infested with the Mexican cotton-boll weevil. Miss. Agr. Expt. Sta. B. 117, 6 p., Dec.
Treats the cultural remedies of the boll weevil, including soil preparation, fertilization, cultivation, varieties, and destruction of favorable hibernating places.

1908 - Newell, W. Destroying the boll weevils before they enter hibernation. La. Crop Pest Comn. C. 24:41-48.
The importance of fall destruction of cotton stalks. Early and complete destruction is a necessary precedent to the successful use of powdered arsenate of lead the following spring.

1908 - Stringfellow, H. C. The boll weevil situation in Texas. La. State Bd. Agr. and Immig. Crop Rpt., p. 7-34. Oct.
Conditions relating to cotton production in weevil-infested regions of Texas. Information secured directly from cotton planters during a tour of investigation made by the author as a representative of the farmers of Ouachita Paris, La. Much valuable information is brought together upon the various cultural practices in vogue and general economic conditions.

1909 - Hunter, W. D. The boll weevil problem with special reference to means of reducing damage. U. S. D. A., Farmers' B. 344:46, 9 fig.
A summary account of practical results obtained from investigations of the cotton boll weevil by the Bureau of Entomology of the U. S. D. A. and is intended to supersede Farmers' B. 216, previously noted. Special attention is given to the life history and habits of the pest. The methods of control which are described in detail are summarized as follows.

1. Destroy the vast majority of weevils in the fall by uprooting and burning plants. This is the all-important step and results in death of millions of weevils. Insures a crop for the following season.
2. Destroy as many weevils that have survived the preceding operation and are found in the cotton fields and along the hedgerows, fences, and buildings. This is done by thoroughly clearing the places referred to.
3. As far as possible, locate fields where damage will be avoided. This cannot be done in all cases but can frequently be done to good advantage.
4. Prepare the land early and thoroughly in order to obtain an early crop. This means fall plowing and winter working of land.
5. Provide wide rows, plenty of space between the rows, and the plants in the drill, for the assistance of the natural enemies of the weevils, which do more against the pest than the farmer can do himself by any known means. Check-rowing, wherever practicable, is an excellent practice.
6. Insure an early crop by early planting of early-maturing varieties and by fertilizing where necessary.
7. Continue the procuring of an early crop by early chopping to a stand and early and frequent cultivation. Do not lose the fruit the plants have set by cultivation too deep or too close to the rows.
8. Where the labor is sufficient, pick the first appearing weevils and the first infested squares. Do not destroy the squares but place them in screened cages. By this means the escape of the weevils will be prevented while the parasites will be able to escape and continue assisting the farmer.

9. Do not poison for the leaf-worm unless its work begins at an abnormally early date in the summer.

10. Do not go to the expense of buying special preparations for destroying the weevil. Disappointment and loss is certain to follow.

1909 - Hunter, W. D. What can be done in destroying the cotton boll weevil during the winter. U. S. D. A., Bur. Ent. C. 107:4.

While the most important step in the control of the cotton boll weevil is the fall destruction of cotton stalks, much effective work can be done while the pest is in hibernation. The raking and burning of trash in cotton fields, the burning of turn rows, ditches, sorghum and corn fields, etc., and the clearing of fence corners and similar situations are particularly recommended.

1909 - Newell, W., and M. S. Dougherty. The "V" cotton stalk cutter. How to make it and how to use it. La. State Crop Pest Comn. C. 30:151-158. Sept. 15.

Contains specification for building the "V" cotton stalk cutter and how to operate it.

1909 - Newell, W. What constitutes a perfect stand of cotton when fighting the boll weevil. La. Crop Pest Comn. C. 25:15.

In sections infested by the boll weevil, cotton bolls are not made after Aug. 15 (and sometimes none after Aug. 1) and, therefore, each plant requires only enough growing room in which to produce bolls up to the date of maximum infestation--about Aug. 15. Having in mind these facts, the author conducted experiments to determine what constitutes a perfect stand--the number of plants on any given area which will give the greatest yield per acre. A summary of the comparative production of widely spaced and closely spaced cotton is presented.

These experiments were conducted on such a variety of soils and under such a variety of conditions that the results are considered trustworthy.

Spacing about as follows gave the maximum yields per acre under ordinary conditions:

On poor upland soil, rows 3 feet apart, plants 10 inches apart in the row.

On rich upland or good prairie soils, rows 3 feet apart, plants 12 inches apart in the drill. For worn, or very sandy bottom lands, rows $3\frac{1}{2}$ feet apart, plants 12 inches apart in the drill.

On bottom lands of medium fertility, well drained, rows 4 feet apart, plants 15 inches apart in the drill.

1910 - Hayhurst, P. How to control the two worst cotton pests, the boll weevil and the bollworm. Ark. Agr. Expt. Sta. C. 4.

The author recommends the production of an early crop. Burn all bolls and rubbish in and about fields in October. Plow stalks under not later than Nov. 1. Plant rows far enough apart to permit sunlight to reach fallen squares. Rotate crops.

1910 - Hunter, W. D. The status of the boll weevil in 1909. U. S. D. A., Bur. Ent. C. 122, 12 p.

The results of experiments with a chain cultivator designed by Dr. W. E. Hinds.

1910 - Newell, W. How to increase the death rate among the boll weevil during winter so as to protect the following year's crop. La. Crop Pest Comn. C. 28:4.

Emphasizes the importance of fall destruction of all cotton plants by cutting them down and burning before Oct. 15, or, at the latest, Nov. 1.

1911 - Anonymous. Experiment station work. XIV. U. S. D. A. Farmers' B. 457:24, 1 fig.

Articles on fighting the boll weevil by clean farming methods, hastening maturity of cotton by fertilizers, etc.

1911 - Cook, O. F. Relation of drought to weevil resistance in cotton. U. S. D. A. B. 220. Aug.

The effect and relation of drought to the weevil and weevil-resistant habits of growth, and the value of varietal and cultural factors that can be utilized in reducing weevil damage.

1911 - Hinds, W. E. Fighting the boll weevil. Ala. Agr. Expt. Sta. C. 6:7.

Calls the attention of cotton growers to the fact that if the cultural methods as outlined are practiced, there will be little difficulty in producing increasingly profitable cotton crops, in spite of the boll weevil.

Suggests: (1) plant early, (2) select seed carefully, (3) pick cotton promptly, (4) vary crops, (5) rotate crops, (6) prepare soil deeply and more thoroughly, (7) pick fallen squares.

1911 - Knapp, S. A. Demonstration work on southern farms. U. S. D. A. Farmers' B. 442:19, 4 fig.

Supersedes Farmers' B. 319.

A statement of the system used for producing cotton under boll weevil conditions includes a discussion of the general principles to be followed: the destruction of weevils, proper preparation of the soil, early planting of early maturing varieties, fertilizing, wider spacing of plants and rows, the use of the harrow, the agitation of stalks by means of brush on the handles of the cultivator or plow, picking up fallen squares, selecting and storing seed, and rotation of crops. The occasional use of topping or of root pruning by means of barring off is suggested as a means of preventing the formation of useless top crop.

1912 - Hinds, W. E. Destroying boll weevils by clean farming. Ala. Agr. Expt. Sta. C. 7. Oct.

Suggests burning, shredding, or plowing residue stalks in the field. Former method only sure one. Clean ditches and turn rows will help to decrease hibernation.

1912 - Hunter, W. D. The control of the boll weevil. U. S. D. A. Farmers' B. 500:14.

Discussion of the basis for means of repression, and provision of a summary of control measures.

1912 - Hunter, W. D. The boll weevil problem, with special reference to means of reducing damage. U. S. D. A. Farmers' B. 512:46.

Outlines practical methods of controlling Boll Weevil:

1. Destroy vast majority of weevils in fall by burning crop residue.
2. Clean adjacent hedge rows, fences, etc.
3. Locate fields where damage can be minimized.
4. Prepare land for planting early.
5. Provide wide rows.
6. Insure early crop by early planting and by fertilizing where necessary.
7. Hand pick weevils if economical.
8. Do not poison leaf worms unless their damage starts early.

1915 - Hinds, W. E. Boll weevil control by cotton stalk destruction. Ala. Agr. Expt. Sta. C. 33. Sept.

Chop and bury stalks under at least 4 inches of dirt, or uproot, pile, and burn.

1916 - Anonymous. Cotton experiments in 1916. Miss. Agr. Expt. Sta. B. 178:40, 3 fig., 19 tab. Dec.

Anthonomus grandis is the chief limiting factor in the production of cotton in Mississippi, where it has gradually spread and increased since 1907. No satisfactory method of control has yet been found, though many have been suggested and tried. Picking by hand during the early part of the season, or collecting the weevils by shaking the plants over a bag, which has a barrel hoop sewed in it to

keep it open, are of no practical value on large plantations. Since cotton is the sole food-plant of this weevil, the cutting off of the food supply in autumn by destroying the cotton stalks would prevent many from hibernating. All dead timber and hollow trees that are the favorite hibernating places should be destroyed, and cotton should not be planted on areas adjacent to woods and forest. The early planting of early maturing varieties of cotton is an additional safeguard.

1916 - Coad, B. R. Cotton boll weevil control in the Mississippi Delta with special reference to square picking and weevil picking. U. S. D. A. B. 382:12. July 8.

The heavy rainfall prevailing in the delta region of Mississippi favors the survival of the cotton boll weevil in fallen squares. Tests were, therefore, made to determine the value of collecting hibernating weevils from the plants in spring and of destroying fallen squares. In 1915 square picking was begun on June 16 and was repeated at intervals of 7 days until July 14. Comparison with a control plot showed an increase of 23% of seed cotton in the picked plot. Beneficial results were obtained by collecting weevils from standing plants, by shaking them into sacks held below the plant and destroying them by means of water covered with a layer of kerosene. This method proved to be superior to hand picking, since, in the latter, weevils were liable to be overlooked or to fall to the ground when plants are disturbed. When, however, the cost of labor was taken into consideration, the margin of profit appeared to be too slight to render these measures of commercial value.

1917 - Bentley, G. M. The cotton boll weevil in Tennessee. Tenn. State Bd. Ent. B. 22, 14 p., 24 fig. Sept. Knoxville.

The status of the boll weevil situation in Tennessee in 1917 for the purpose of familiarizing cotton growers with the habits of Anthonomus grandis and methods of dealing with it. Of these, the most effective involved the starvation of late broods by doing away with the cotton which develops from late maturing bolls, and the selection of strains of early maturing cotton, the growth of which may be further advanced by intensively cultivating a small acreage. Dusting with lead arsenate also proved efficacious, the poison being taken up by the boll weevil in drinking the rain or dew adhering to the plant.

1917 - Coad, B. R., and T. F. McGehee. Collection of weevils and infested squares as a means of control of the cotton boll weevil in the Mississippi Delta. U. S. D. A. B. 564:51, 2 pl. Oct. 4.

The experiment on cotton boll weevil control made in 1915 was continued with the special object of ascertaining the value of various methods of collecting boll weevils and infested cotton bolls as a means of control. It was found that picking operations were a complete failure in exerting any appreciable effect on the infestation, the maximum amount of benefit being derived during a year of light infestation. In average years there is a great excess of weevils for producing the maximum injury to the crop, and a considerable number of these can be removed without appreciably increasing the crop secured. This is especially discouraging in view of the fact that in a year of heavy infestation the control measure is most needed.

The use of the bag-and-hoop as a means of collecting the weevils proved to have a most injurious effect on the plants. The loss of the terminal buds, due to the shaking, and the constant bending resulted in a dwarfed bushy growth. A mechanical collector driven between the rows while the plants were violently agitated was equally unsatisfactory, badly breaking the stems when driven close enough to catch the weevils. As a mechanical picker seemed to be the only solution to the labor problem involved in the collection of the weevils and squares, failure to give satisfactory results was very discouraging.

1917 - Pierce, W. D. How insects affect the cotton plant and means of combating them. U. S. D. A. Farmers' B. 890:27, 36 fig. Dec.

The principal pests of cotton are dealt with, the particular damage done by each being indicated. The squares, flowers, and buds are damaged by Anthonomus

grandis. A single system for cotton-insect control is described, the measures for each season being indicated. Early in spring weeds should be kept down and poison-bait traps laid wherever necessary for cutworms, grasshoppers, etc. Planting should be as early as possible, while avoiding frosts. Prolific varieties that fruit rapidly should be chosen to suit the locality. For summer treatment, cultivation should be continued until the crop is gathered or as long as possible. In the autumn the cotton crop should be gathered without delay and then the plants destroyed by plowing under or grazing as early before frost as possible.

It is advisable to follow a 3-year rotation with cotton following some crop other than maize. In winter all fence rows should be cleared, weeds cut and burned, stubble fields plowed and old stumps rooted up.

1917 - Williams, J. W. How to grow cotton in spite of the boll weevil. Ga. State Bd. Ent. B. 47, 48 p., 9 pl. Feb. Atlanta.

This bulletin outlines plans for growing cotton by methods that secure the best conditions and the maximum results in the presence of the boll weevil. Emphasis is laid on the necessity for destroying cotton stalks in the autumn as soon as the cotton is harvested. This reduces the number of weevils that live through the winter. The ground should be thoroughly prepared in the autumn and harrowed 2 or 3 times during the winter. No cover crop should be planted after or before cotton. When the weevil first appears the colonies should be stamped out, when possible, by killing the weevils and taking up the first plants that show infestation.

1920 - Anonymous. Experiments with green bolls of sea island cotton. Agr. News 14(468):101. Apr. 3. Barbados.

The Spence-Harvey system of treating green cotton bolls is said to lessen, materially, the damage caused by the boll weevil in the United States. Under this system the bolls are gathered while green and mechanically matured by a special process. They are then treated by special machinery so as to extract the cotton. Only 2 machines are at present in operation, though it is expected that upwards of 100 will be made during 1920.

1920 - Anonymous. The boll weevil - 16th annual report, 1917. S. C. Comn. Agr. Com. & Ind., p. 265-288. Columbia.

The results of dusting as a remedy against the boll weevil are briefly discussed. No definite recommendations in favor of a method is considered possible at present. It is pointed out that the general practices advocated against the pest are practically the same as those demanded in good farming. The acreage planted with peanuts in South Carolina is increasing, and it is thought that this crop might profitably be substituted for cotton in many districts.

Prof. A. F. Conradi is of the opinion that the boll weevil will, in the future, be a permanent limiting factor in cotton production in the State. He considers that the poisoning methods warrant a thorough investigation of its merits, and thinks that early failures were due to the crude state of the poisons and the apparatus for applying them. Mr. Sevinton Whaley's advice, after the severe infestation of 1919, was to resort to diversified methods of farming, cultivating cotton only as a surplus crop; to use the intensive system and poison with calcium arsenate.

1921 - Anonymous. The boll weevil - 17th annual report, 1920. S. C. Comn. Agr. Com. & Ind., p. 130-138. Columbia.

The menace of the infestation by the boll weevil in S. C. in 1920 was so clearly foreseen and farmers so far protected themselves by diversified agriculture that the calamity was much less than had been anticipated; in fact, careful farmers in the boll weevil area were more prosperous than those in parts of the State remote from the infested area who gave their entire land to cotton growing. The various agricultural practices adopted by the different counties of S. C. in this respect are reviewed by various authors.

1922 - Anonymous. Farming under boll weevil conditions. N. C. Agr. Ext. Serv. C. 124, 22 p. Feb.

Defines counties in which damaging and light infestations are to be expected and cultural methods to be employed to minimize damage. Also includes an article entitled "Poisoning Cotton-Boll Weevils" by B. R. Coad, Bureau of Entomology U. S. D. A.

1922 - Smith, G. D. A preliminary report upon an improved method of controlling the boll weevil. Fla. Agr. Expt. Sta. B. 165, 72 p. Oct.

Reviews past efforts to control the boll weevil. A proposed method consists in clearing cotton fields, early in June, of all adult weevils and at the same time destroying their eggs and larva, leaving plants to grow without interference for a succeeding 8 weeks. Shows that through use of hand removal of squares and use of calcium arsenate at a cost of $1.01 to $1.72 per acre, increase yield values of $9.69 to $33.63 were obtained.

1922 - Smith, G. D. Preliminary report upon an improved method of controlling the boll weevil. Fla. State Plant Bd. 2.B. 7(1):1-64, 13 fig. Oct. Gainesville.

A study of boll weevil conditions in Florida suggested that the first generation of weevils could be destroyed by stripping from the cotton plants the first squares of the season, and with them the eggs deposited by the weevils after hibernation. Care must be taken that all weevils are out of their winter quarters before this is done. In normal seasons the squares should be removed between June 5 and 8, and this should be followed by a thorough application of calcium arsenate or lead arsenate at the rate of 5 to 7 lbs. per acre, using a suitable dusting machine. The weevils, deprived of squares in which to hide and feed, will attack the terminal buds for food, and these buds can easily be filled with poison by means of a dust gun. This method has been found to destroy practically every weevil that had escaped capture in the stripping operation. A table recording emergencies of the weevils at various places shows that 99% are out of hibernation and in the cotton fields by June 5. In order to get the plants into the right fruiting stage for treatment, nonfertilized cotton should be planted about the last week in March. If fertilizer is needed, planting should be done one week later. If the season is unusually late, the treatment should be delayed for a few days, until enough squares have appeared on the plants to act as traps for the adult weevils.

The effect of stripping the squares on the yield of cotton is discussed, and the life history of the weevils under Florida conditions, with a view to satisfactory application of the remedies, is dealt with. The second generation of weevils matures about August 5, at the earliest, and by this time the Florida crop of short staple is sufficiently matured to escape practically all damage by the weevils. Many field tests with these methods are recorded in detail, and the best method of removing the squares and of applying the poisons are explained.

1922 - Hunter, W. D., and B. R. Coad. The boll weevil problem. U. S. D. A. Farmers' B. 1262, 31 p., 5 fig. Feb.

A general account of the boll weevil in the United States is given. The remedial measures suggested are based largely on cultural methods. Where poisoning is required, calcium arsenate should be used in the manner that has been shown to give good results.

1923 - Cook, O. F. Boll weevil cotton in Texas. U. S. D. A. Dept. B. 1153, 18 p., 4 pl., May 12. Wash.

Boll weevil cotton is the expression used to describe the effects of injury by the boll weevil in cotton plants, which are forced into rank growth and show an abnormal luxuriance that changes the form and appearance of the plants. As the insects during periods of dry weather are dependent upon the protection afforded by this thick growth, the advantage of cultural methods that will keep the lanes open between the rows is obvious. Wider separation of the rows, combined with closer spacing of plants in the rows, is a practical method of culture that is advantageous in dry seasons as well as under conditions of boll weevil cotton. The

indications are that the rows should be not less than 4 feet apart and the plants not more than 6 inches apart in the rows to give the best assurance of suppressing secondary stalks, keeping the lanes open between the rows and avoiding boll weevil cotton. In case of emergency the cutting out of alternate rows might be advisable.

1923 - McDonald, R. E. The boll weevil - A review of the methods of control. Tex. Dept. Agr. B. 74, 21 p., 1 map, Jan.-Feb. Austin.

There is no known successful method of eradicating the cotton boll weevil. The various practices adopted are reviewed, their efficacy depending on the region of the State in which they are employed and the prevailing weather conditions. The necessity for concerted community action with the adequate legislation that it requires is pointed out.

A map is appended showing the range of infestation in Texas in 1920-1922.

In the introduction of this bulletin, G. G. Terrell recommends the plowing under of the green cotton stalks as early in the autumn as possible. Owing to the resulting lack of food, many of the weevils die before going into hibernation. This method has the further advantage of improving the soil for the next crop.

1924 - Conner, A. B., and H. J. Reinhard. Cotton boll weevil control in Texas. Tex. Agr. Expt. Sta. C. 32, 14 p., May. Col. Sta.

The life history of the cotton boll weevil and the history of its effect upon cotton production in Texas. The question of control, which resolves itself into one of good farming, is also dealt with. Every effort should be made to destroy the cotton plants in the autumn as soon as the crop is harvested and to provide the best conditions for fruiting, thus ensuring profitable yields, even under boll-weevil conditions. In individual cases, spraying with calcium or lead arsenate may prove necessary.

1924 - Pierce, W. D. How insects affect the cotton plant and means of combatting them. U. S. D. A. Farmers' B. 890, 25 p. Dec. 1917, Rev. Jan.

Includes discussion of the boll weevil with calcium arsenate as a control measure and lists several cultural methods which would be of help in controlling the boll weevil.

1924 - Smith, G. D. Further experiments with the Florida method of boll weevil control. Fla. State Plant Bd. Q. B. 8(2):27-72, 9 fig. Jan. Gainesville.

During 1923 further experiments were made with the Florida method of control for the cotton boll weevil, particularly with regard to weather conditions and with a view to finding a method of applying the poison that would give quicker mortality.

The results of this work are summarized as follows: In most cases where the Florida method was properly used, a profitable crop of cotton was secured. Weather conditions during the growing season of 1923 practically prohibited successful dusting of the cotton plants. A poisoned syrup mixture made by mixing 2 lbs. of calcium arsenate in $\frac{1}{2}$ U.S. gals. of water and then adding 1 U.S. gal. of syrup (treacle), when mopped in the buds of the cotton plants, gave much better results than dusting. Syrup is not attractive to the weevil in the sense that weevils will search for it and congregate around it in numbers. Mortality records secured under cage conditions, and later verified by field experiments, show that after the squares are removed and the buds of the plants mopped with the poisoned syrup mixture, most of the adult weevils are killed within 24 hours.

Powdered calcium arsenate dusted on the plants by means of a dust gun required from 48 to 72 hours to give about the same results. Mopping the plants after the squares were removed, using the poisoned syrup mixture, was found to be cheaper than making one application of calcium arsenate dust, using a rotary fan type of dust gun at the rate of 5 lbs. per acre. The Florida method of weevil control can be effectively used under adverse weather conditions if the poison is applied in the form of the poisoned syrup mixture.

The cost of removing the squares varied from about $0.54 to $1.90 per acre, depending on the space of the plants in the row and the number of squares on the

plants at the time of stripping. Any kind of syrup can be used, but the better the grade of syrup, the higher the percentage of control that will be secured. It is desirable that the mixture retain its syrupy consistency as long as possible.

Mopping, with mops made by tying shucks or pieces of burlap on the end of a stick, was found to be more successful than shaking the syrup mixture out of a bottle. By gently pressing the mop down into the bud of the plant there is practically no chance of the weevil escaping the poisoned-syrup mixture. On the other hand, if a drop or two of the mixture is shaken from a bottle onto the top leaves of the plant, there is a chance that the weevil will not find the poisoned syrup until after it has been rendered harmless, either by dew or rapid evaporation.

Recommendations are given for cotton growing in 1924, including the application of the Florida method described above. On very fertile lands it might be profitable to lengthen the period of weevil protection by giving one or two applications of calcium arsenate during July, or when the infestation of squares has reached 15% or 20%. Such late applications are expensive and are not likely to be profitable on poor or average land. The cotton crop should be picked as fast as it opens, and immediately after harvest all plants should be totally destroyed.

1925 - Ballard, W. W., and D. M. Simpson. Behavior of cotton planted at different dates in weevil-control experiments in Texas and South Carolina. U. S. D. A. Dept. B. 1320, 43 p., 5 pl. 10 fig. Apr. Wash.

In order to obtain data on the growth and fruiting habits of early and late planted cotton in relation to the cultural control of the boll weevil, many experiments were made in 1923 and comparisons were drawn between the behavior of early and late plantings in Texas and South Carolina. The differences in the rates of growth and the fruiting habits of the plants are discussed in detail. In view of variations in results and of the fact that the later rows of successive plantings were only partly protected against weevils from the earlier rows, the experiments were in no way conclusive.

1926 - Hunter, W. D. The cotton hopper or so-called "cotton flea." U. S. D. A. Dept. C. 361, 15 p., 4 fig., 5 ref. Aug. Wash.

"In 1924 cotton planted between May 1 and May 15 was damaged more by P. seriatus than that planted before or after. It was concluded that early planting is preferable to late, as in more normal seasons cotton planted after May 15 would probably be severely damaged by the boll weevil . . ."

1926 - Sanborn, C. E. Boll weevil in Oklahoma, especially during the years 1921 to 1925. Okla. Agr. Expt. Sta. B. 157, 32 p., 10 pl., 4 fig., Feb. Stillwater.

General recommendations are to insure correct time of planting, using an early maturing variety of cotton, and to retain a continuous soil mulch until the bolls begin to open. In cases of severe infestation over a large area, the whole community should practice early gathering of the infested squares. Punctured squares should be gathered for 6 weeks after the first ones appear and placed in a parasite cage. Final picking of cotton should be completed as early in autumn as possible, and all plants should be destroyed immediately afterwards and the fields thoroughly cleaned up. After ginning is completed, all gin trash should be removed and enclosures prepared for seed and bolls, so that hibernating weevils can only escape into screen traps. Cotton fields and seed beds should be prepared in advance, and made compact, moist, and warm, to insure uniform germination and quick growth. Only as much cotton should be grown as can be thoroughly cared for.

1927 - Cook, O. F., and C. B. Doyle. Sea Island and meade cotton in the southern States. U. S. D. A. Dept. C. 414, 19 p., 1 fig., 7 ref. May. Wash.

Though early in the season, Sea Island cotton affords less opportunity than upland cotton for the breeding of boll weevils. In the later stages of development the former variety is the more susceptible of the two to injury, owing to the thinner walls and softer texture of the bolls. The experiments showed that heavily fruited plants of sea-island cotton may have the crop completely destroyed by

weevils in a few days of wet weather, while adjacent plantings of upland cotton showed much less damage to the bolls.

In consequence of the necessity of making the tests with the two varieties of cotton growing side by side and the impossibility of protecting the Sea Island cotton (which requires a longer season to mature a full crop) from weevils that may breed on the upland cotton, it was difficult to determine the greater extent of damage to Sea Island cotton.

Control by means of poisons was not practicable in the wet weather which often prevails in the coast districts at the critical stage of the fruiting season, and precautionary measures were only of value where there is whole-hearted cooperation on the part of the growers. The author suggests that weevil injury might be avoided by planting cotton only in alternate years in isolated districts where one variety is grown exclusively, since the weevils do not breed on other plants and could not multiply if no cotton were planted in the intervening years. The importance of the established restrictions on the import of cotton seed is emphasized.

1927 - Morrill, A. W. Observations on Bucculatrix Gossypiella, a new and important cotton pest. J. Econ. Ent. 20(3):536-544.

In the Yaqui Valley area in Mexico, - "April and May appear to be a more favorable time for planting cotton than February and March from the point of view of controlling B. gossypiella and A. grandis." Should further investigations confirm this, the author suggests a Government regulation prohibiting the planting of cotton before April 15 and requiring the destruction of cotton stalks before January 15, or some other specified date.

1928 - Hinds, W. E. The effect of the spacing of cotton upon the form and height of the plant. J. Econ. Ent. 21(5):741-748.

Results of tests carried out from 1924 to 1926 on Mississippi River bottom soil to determine the effect of spacing of cotton upon the yield secured, particularly under conditions of infestation by the boll weevil. Previous tests showed that in practically all cases it is advisable to plant the rows as closely as possible with due allowance for the normal height of the plants and the culture required, and also to leave the plants much thicker in the row than had hitherto been the custom. In the tests described, hill spacing with 3 to 5 stalks at 1 or 2 feet apart appeared to be the most practicable and desirable.

1930 - Isely, D. Ark. Agr. Expt. Sta. 42d. Ann. Rpt. B. 257:54-55. Nov.

An experiment in control of boll weevil by destruction of places in which it might hibernate was undertaken in Crawford County--600 acres on 12 farms. All woodland within or bordering was subject to overflow or had no high pastures or other high land subject to cultivation. Actual adjacent land requiring cleanup was less than 5 acres, or less than 1% of the total acres of woodland. Winter of 1929-30 temperature was as low as $9^{o}F$. Nevertheless, boll weevil survived in fair numbers and was found in 8 out of 10 fields outside the cleanup area. No injury in the test area was found in 1930. A trace of infestation was found in a single spot near the margin of the field.

1932 - Folsom, J. W. Insect enemies of the cotton plant. U. S. D. A. Farmers' B. 1688, 28 p. July.

A revision of and superseding Farmers' Bulletin 890, How Insects Affect the Cotton Plant and Means of Combating Them.

Rotation of crops is of assistance in controlling many cotton pests. Weeds should not be allowed to grow near the cotton, for many pests come to the cotton from other crops or from weeds around the fields. Thorough fall plowing, winter cover crops, early spring population, and repeated cultivation during the season are important measures of insect control. An early crop is necessary. The cotton plants should be turned under in the fall, if possible, before frost. Descriptions are presented of many cotton insects, including the boll weevil, and their work with suggestions for their control.

1934 - Isely, Dwight. Relationship between early varieties of cotton and boll weevil injury. J. Econ. Ent. 27(4):762-766.

Controlled experiments were conducted in Arkansas from 1926-1929, using a strain of Trice (a very early cotton), Acala (an early strain) and Snowflake (a late variety). In 1927 Rowden was substituted for Snowflake. Under average conditions late varieties were shown to carry a much greater weevil hazard. There was less to be gained by dusting early, rapidly maturing cotton.

1934 - Sanborn, C. E., H. C. Young, E. Hixson, E. E. Scholl, and C. F. Stiles. History and control of the boll weevil in Oklahoma. Okla. Agr. Expt. Sta. B. 222:32.

An account of work carried out in Oklahoma during 1921-34 on the control of the cotton boll weevil, the bionomics of which are outlined. Cultural measures are recommended, supplemented where necessary by the application of a calcium arsenate dust every 4 or 5 days after the infestation has reached 10%.

1934 - Robinson, J. M., and F. S. Arant. Entomology. Ala. Agr. Expt. Sta. Rpt. 44:27-29. Auburn.

Studies on the control of the boll weevil with calcium arsenate dust were continued in 1932. Of 10 applications made during the fruiting season, 4 were affected by rain within 24 hours, the yields of cotton were slightly above the average for the past 6 years, and there was a definite increase on all fertilized plots that had been dusted. The increased yields from dusted cotton were 213, 128, 426, and 400 lbs. of seed cotton per acre on the plots receiving 500, 1,000, 1,500 and 2,000 lbs. of fertilizer per acre, respectively.

1941 - Calhoun, P. W. Topping cotton in early fall as a possible means of reducing the spring boll weevil population in the northwestern part of the Florida Sea Island cotton belt. Fla. Ent. 24 (2):35-40, 5 ref. Gainesville.

The investigations were carried out in view of the exceptionally large numbers of boll weevils that develop in autumn in cotton bolls in the upper parts of the plants in the northwestern part of the Florida Sea Island cotton belt. These populations commonly exceed 10,000 weevils per acre, and control was so difficult that the growing of Sea Island cotton on a large scale generally had to be abandoned.

An experment was made in the autumn of 1940 over some 200 acres of heavily infested cotton; most of the fields had produced less than half their crop. Almost all the bolls on the upper half of the plants contained 2 to 5 larvae or pupae, while the tops were producing an abundance of squares. The plants were topped on September 10, about 10 days before the final picking; the upper parts (about one-third of each plant) that contained bolls severely infested with advanced stage larvae or pupae were cut off, in order to destroy as much of the squaring portion as possible without discarding any sound bolls. As soon as the discarded tops died, the adult weevils feeding on them moved back to the plants, and fed on the few remaining squares and on bolls that were not ready to open. As the population had already been high for several weeks, nearly all the sound bolls were tough, fibrous and almost ready to open. About two weeks after topping, the adult weevils began to decrease in numbers, until only a few remained. Whether most of them died or migrated is not known. The immature stages died in great numbers in the young bolls on the removed tops, and the percentage emergence was much lower than it would have been had the tops remained on the plants. The bolls on the living plants that had been attacked, but not completely ruined by the weevils, apparently opened more quickly and fully as a result of topping, which seemed to result in less waste cotton being left in the field at the final picking. It is thought that the cost of the operation was more than covered by the increase in the amount of the cotton harvested.

If an abundance of squares in autumn helps the weevil to survive the winter, the scarcity of squares in the fields that have been topped will decrease the percentage of survival of the relatively few weevils that remain, and so increase the effect of the reduction in the population caused by the topping. If practiced cooperatively on a sufficiently extensive scale, topping should thus prevent the

occurrence of the heavy spring populations that are common in the northwestern part of the Florida Sea Island cotton belt. It is not recommended for the central and southern parts of this belt, however, as the same result can be better obtained there by early picking followed by prompt destruction of the stalks.

1941 - Glick, P. A., and K. P. Ewing. Studies of insect damage to cotton with reference to soil-conservation practices. J. Econ. Ent. 34(6):737-741.
Studies that are being made to determine the effort of the latest farming and soil conservation practices on insects injurious to cotton in the Blacklands of Texas. The plan of operation, the records made, the scope of the insect studies, and the methods of making population counts of the different insects are described. Detailed seasonal infestation records are being made of the boll weevil, and the records are made of any unusual outbreaks of other insects on cotton. The survey has been in operation for only 2 years, and no trends are so far evident; it is anticipated that the work will not be completed for at least 9 or 10 years.

1942 - Robinson, J. M., and E. L. Mayton. Yield in cotton due to control of boll weevil. Ala. Agr. Expt. Sta. 52d ann. Rpt. 1941:27-32.
Results of experiments in 1924-41 in which the gain in yield of cotton due to the control of boll weevil by dusting with calcium arsenate, in years in which the amount of infestation required it, increased with the amount of fertilizer applied to the plots.

1943 - Dunnam, E. W., J. C. Clark, and S. L. Calhoun. Effect of the removal of squares on yield of upland cotton. J. Econ. Ent. 36(6):896-900.
Experiments conducted at Stoneville, Miss., in 1939, 1940, and 1941, to determine the influence of square removal on yield of upland cotton. All squares over 6 or 7 days old were removed at weekly intervals for 1 to 9 weeks; and from 10% to 50% were removed at weekly intervals for 7 to 11 weeks. Indications were that the square removal would result in a reduction of yield. The greater square production which followed dusting with calcium arsenate in the absence of an appreciable number of boll weevils was not manifested in increased yield.

1946 - Ewing, K. P., C. A. King, Jr., and F. L. Thomas. Fight the boll weevil now by plowing under the cotton stalks. Tex. Agr. Expt. Sta. Prog. Rpt. 1000-T. Oct. 15.
Recommends the practice of destroying cotton stalks on a community-wide basis, before frost, to reduce boll weevil infestations in the following season. In States where conditions permitted, the early fall destruction of cotton stalks was the last step in making the cotton crop of 1946 and the first step in making the 1947 crop more economical and more profitable.

1949 - Gaines, J. C., and H. G. Johnston. Acco. Press 15-18. M. June. Houston, Tex.
Report of the results of a fall stalk destruction program which was conducted on a voluntary basis in Williamson County, Tex., during 1947. Stalks were destroyed early by all planters in the county and weevil infestations were greatly reduced the following year.

1950 - Watts, J. G. Maximum profit from cotton fertilizer dependent upon insect control. S. C. Agr. Expt. Sta. Ann. Rpt. 61:91-92. May.
Adequate nitrogen is necessary for profitable cotton production, but an excess can delay the setting and maturing of the bolls. In an experiment where several rates of nitrate of soda side dressing were used, as the rate of application increased, the percentage of the crop harvested at the first picking decreased. This was true whether or not the cotton was dusted for weevil control. The delay in setting and maturing fruit, following the higher nitrogen applications, exposed more of the squares and small bolls to heavy boll weevil attacks. As a result of delayed fruiting and incomplete weevil control, the application of 100 pounds per acre of nitrate of soda produced more cotton than did 200 and 400 pounds. Where there was no weevil control, more cotton was harvested from

plots which received no side dressing than from those which were side dressed. This emphasizes the importance of an effective weevil control program if the added benefits of fertilization are to be fully realized.

1951 - Hamner, A. L. Cotton fruiting in relation to insect control. Assoc. South. Agr. Workers Proc. 48:96.

The fruiting cycle of cotton plants grown in fertilized and unfertilized soils of 7 different types was determined for a 3-year period. Neither soil types nor fertilization made enough difference in the fruiting to require any change in insect control recommendations. The 3-year averages for the fertilized plots of all soil types show that 8.13% of the total season's flower production occurred during the first week, and the bolls developing from these flowers produced 20.41% of the total seed cotton. During the fifth week 9.84% of the total flowers were produced, but the bolls developing from these flowers yielded only 2.23% of the total crop. The 3-year average percent of the total yield set during the first 4 weeks was 96.5% for the fertilized plots and 94.9% for the unfertilized. Bolls developing from each succeeding week's flowers were lighter than those developing from the preceding week through the fourth week.

1952 - Elliott, Fred C., and Allen C. Gunter. Early cotton stalk destruction will pay. Tex. Agr. Ext. Serv. L-173. Aug.

Emphasizes advantages of early stalk destruction in preventing carryover of pink bollworms and reducing number of weevils to infest next year's crop, besides being a good practice in preparing land for the next crop.

CONTROL - BIOLOGICAL

1901 - Rangel, A. F. Tercer informe acera del picudo del algodon. Comn. Parasit. Agr. B. 1(6):197-206. Mexico.

The occurrence of the mite *Pediculoides ventricosus* upon the egg and larva of the boll weevil is noted for the first time.

1902 - Ashmead, W. H. A new bruchophagus from Mexico. Pysche 9:324. Mar.

Contains the description of *Bruchophagus herrerae* n. sp., a parasite of *Anthonomus grandis* from Coahuila, Mex.

1903 - Anonymous. El parasito del picudo. El Prog. de Mex. 10:284.

Note regarding work of the Comision de Parasitologia with the mite *Pediculoides ventricosus* Newport.

1904 - De La Barreda, L. El picudo del algodon. Comn. Parasit. Agr. C. 6, 35 p. Apr. 27. Mex.

The work upon the boll weevil conducted by the Bureau of Entomology is outlined and a statement is made regarding loss due to the pest in portions of Mexico. Portions of an article in the Yearbook, U. S. D. A. for 1903 are translated. The work of the Commission is reviewed by giving quotations from some of its previous publications. The work upon the mite *Pediculoides ventricosus* is given the greatest amount of attention.

1904 - Cook, O. F. Report on the habits of the kelep, or Guatemalan cotton boll weevil ant. U. S. D. A. Bur. Ent. B. 49, 15 p.

An account of the importation of the "kelep" (*Ectatomma tuberculatum* Oliv.) into the United States, with notes on the habits of the insect.

1904 - Cook, O. F. An ant enemy of the cotton-boll weevil. U. S. D. A. Rpt. 78:7. May 27.

A large reddish brown ant was found by Cook in Guatemala to attack the boll weevil. No identification is reported.

1904 - Hunter, W. D. Ants and the boll weevil. Farm & Ranch 23:16. June 11.
Report on the relation of an ant, Solenopsis debilis texana, to the boll weevil in certain cotton fields in Bexar County, and a general statement regarding its usefulness.

1904 - Valle, Alfrido del. Enemigas vegetales y animales del algodonero. El Prog. de Mex. ano 11, p. 503-504, Aug. 30, p. 515-16. Sept. 8.
Natural enemies are mentioned.

1904 - Wheeler, W. M. On the pupation of ants and the feasibility of establishing the Guatemalan kelep or cotton weevil ant in the United States. Science, n.s. v. 20: 437-440. Sept. 30.
Discussion of some of the habits of the kelep and reasons why the author believes that this species cannot be established successfully in the United States.

1904 - Wheeler, W. M. Some further comments on the Guatemalan boll weevil ant. Science, n.s. v. 20:766-768. Dec. 2.
A further discussion of the improbability of successfully establishing the kelep in the United States.

1905 - Cook, O. F. The social organization and breeding habits of the cotton protecting kelep of Guatemala. U. S. D. A. Bur. Ent. Tech. Ser. B. 10, 55 p.
Observations upon the social organization and breeding habits of the kelep (Ectatomma tuberculatum Oliv.) and reference to its importance as an enemy of the boll weevil.

1905 - Newell, W. The Mexican cotton boll weevil. Ga. State Bd. Ent. B. 12, 29 p., fig. 21.
The cotton boll weevil is described in its various stages, and notes are given on the various other phases of the weevil problem, such as the rate of increase and destructiveness of the pest, artificial remedies, the relation of birds to the boll weevil, and insects frequently mistaken for this pest.

1906 - Anonymous. El picudo del algodon. El Prog. de Mex. 12:64, 74-75, 88-89, 99-101, 115-117, 131-132.
A brief outline of the work carried out by the Comision de Parasitologia during 1905 and the plan of work for 1906. The various methods of control are discussed at length. These include the seed to be used, method of preparing the soil, planting, cultivating, using trap plants, shaking the weevils from the plants, using special machines, the breeding and distributing a native ant--the kelep or Guatemalan ant--using poisons, planting of special varieties of cotton, and various ideas regarding weevil control. New projects to be undertaken by the Comision are mentioned.

1906 - Bailey, V. Birds known to eat the boll weevil. U. S. D. A. Bur. Biol. Survey B. 22, 16 p.
On account of the serious damage caused by the boll weevil in the Southern States, a special effort was made to obtain reliable information concerning birds which feed upon this pest and the amount of assistance which may be expected from them in protecting the cotton crop.
Considering the fact that for the past 12 years the weevil has been steadily spreading over the cotton belt, it appears that birds cannot be depended upon to exterminate the pest. As a result of field observations and examinations of birds' stomachs in the laboratory, a considerable list of birds was determined as feeding upon the weevil. This list includes Carolina wren, titlark, tonitit, western meadow lark, Florida meadow lark, common phoebe, redwing blackbird, white throated sparrow, western savanna sparrow, brown thrasher, Texas bobwhite, blackbird, cowbird, jackdaw, mocking bird, butcherbird, killdeer, and others of less importance.

The total number of stomachs examined, exclusive of mourning doves and quail, was 570. Of this number, 78 contained boll weevils. The weevils were not numerous at the time when the birds were collected. As a result of this study, the author urges the protection of insectivorous birds within the cotton belt.

1906 - Howell, A. H. Birds that eat the cotton boll weevil. A report of progress. U. S. D. A. Bur. Biol. Survey B. 25, 22 p.
Notes on the abundance of several species of birds occurring in cotton fields and their importance as weevil destroyers, as based on numerous stomach examinations.

1907 - De La Barreda, L. Las Plagas del algodonero. Comn. de Parasit. Agr. B. 4(2): 107-215, 24 pl., 1 map. Mex.
A presentation of the answers to a set of questions sent out by the Comision regarding cotton pests, including the boll weevil. Comments upon the replies. Many references made to natural enemies.

1907 - Crawford, J. C. New hymenopterous parasites of Anthonomus grandis Boh. Canadian Ent. 39:133-134. Apr.
Original description of Torymus anthonomi, Urosigalphus anthonomi, and Urosigalphus schwarzi, all reared from the boll weevil.

1907 - Henshaw, H. W. Value of swallows as insect destroyers. U. S. D. A. Bur. Biol. Survey C. 56:4. Apr. 27.
Attention is called to the importance of the swallow in the destruction of boll weevils and other injurious insects.

1907 - Henshaw, H. W. Birds useful in the war against the cotton boll weevil. U. S. D. A. Bur. Biol. Survey C. 57:4.
It has been found that 38 species of birds eat the cotton boll weevils to a greater or lesser extent. In this connection special mention is made of orioles, nighthawks, and various kinds of swallows and martins.

1907 - Herrick, G. W. The boll weevil. Miss. Agr. Expt. Sta., C. 7 p. Sept.
A paragraph is devoted to the relation of birds to the boll weevil.

1907 - Hinds, W. E. An ant enemy of the cotton boll weevil. U. S. D. A. Bur. Ent. B. 63(3):45-48.
The ant Solenopsis geminata Fab., var. xyloni McC., in its relation to the boll weevil.

1907 - Hinds, W. E. Some factors in the natural control of the Mexican cotton boll weevil. U. S. D. A. Bur. Ent. B. 74, 79 p.
If there is an average amount of moisture in the soil up to the time when squares begin to form, followed by a period of 4 to 6 weeks of hot dry weather, the weevils may be so effectively checked as to do little injury to the cotton crop of that season.
An extreme drought, even with average temperatures, will greatly reduce the number of weevils, but the crop will be small due to the lack of rain.
Winter conditions of unusual severity, with frequent low temperatures and much rainfall, reduce the number of weevils surviving hibernation and prevent the survival of old cotton roots. Defoliation of cotton by the cotton leafworm may be a very important factor in reducing the number of weevils in a field which may enter hibernation or which are likely to survive.
Fallen forms contain 70% of the weevil stages developing in a field. The mortality occurring in fallen forms is 4 times as effective in controlling the weevil as is that in hanging forms. Less than $\frac{1}{2}$ of all the weevil stages were alive when found. All factors of natural control seem to operate more effectively against weevil stages in squares than against those in bolls.

The data used in this bulletin includes examinations in 29 localities in several fields in each locality, and in 17 places examinations upon from 2 to 9 times between June 15 and October 15, 1906. More than 86,000 forms were examined, and 39,000 weevil stages were found.

Nearly all of the 11 localities having an average total mortality above the average of the 28 localities examined are south of the center of cotton production in Texas. Ants are more important in the summer control of the weevil than are heat and parasites combined. The mortality from heat in 2 groups of localities having almost identical mean maximum temperatures varies as widely as between 7% and 27%.

Nearly 70% of all mortality from heat or drying occurred during the larval stage. The ratio of mortality percentages in each weevil stage from heat is adult, 1; pupa, 3; larva, 9.

In examination of about 11,000 fallen forms collected between August 10 and August 31, 1905, 25% were squares, and 75% were small bolls. In examination of 62,593 fallen forms collected between June 15 and October 15, 1906, 64% were squares and 36% were bolls. Among 24,363 hanging forms examined in 1906, 28.6% were squares and 71.4% were bolls.

Of 11,000 forms from Louisiana in 1906, only 44% contained a weevil stage. The balance of 56% contained many which had been injured by the feeding of the weevils. Among the bolls, 30%, and among squares, 60% contained some stage of the weevil.

In examinations of forms from Texas in 1906, among more than 14,000 dried, hanging bolls, hardly 25% showed any stage of the weevil; among over 20,000 fallen bolls, only 18% had any stage; among 5,600 hanging dried squares, nearly 60%, and among more than 36,000 fallen squares, slightly over 60% contained a weevil stage.

1907 - Howell, A. H. The relation of birds to the cotton boll weevil. U. S. D. A. Bur. Biol. Survey B. 29, 30 p., 1 pl., 6 fig.

Birds cannot be depended upon to control the boll weevil, but they assist in keeping it in check. As a result of 5 years' work, 43 species of birds have been found to feed on the boll weevil, 23 principally in summer. Suggestions are made regarding State legislation needed to protect certain of these birds.

The most important birds in the control of the boll weevil are swallows, orioles, blackbirds, and meadow larks. Detailed statements are given regarding the extent to which different species of birds feed upon the boll weevil.

1907 - Hunter, W. D., W. Newell, and W. D. Pierce. The insect enemies of the cotton boll weevil. La. State Crop Pest Comn. C. 20, 7 p. Dec.

Brief general account of the parasitic and predaceous insect enemies of the boll weevil, with suggestions for increasing their usefulness.

1907 - Morgan, A. C. A predatory bug reported as an enemy of the cotton-boll weevil. U. S. D. A. Bur. Ent. B. 63(4):49-54, 2 fig.

A report was received that Apiomerus spissipes Say. was attacking the cotton boll weevil. A study was made of this insect, giving attention to its life history, food habits, distribution, and natural enemies.

The results were unfavorable to the supposition that the insect is of value in controlling the cotton boll weevil. It is comparatively rare in cotton fields, especially during the time when the weevils are most numerous and the young insects show a high rate of mortality.

1907 - Pierce, W. D. On the biologies of the Rhynchophora of North America. Nebr. State Bd. Agr. Ann. Rpt., p. 269, 295-307.

Brief history of the species and a list of its parasitic enemies. Pages 295 to 307 contain a description and comparison of the pupae of Anthonomus grandis with other species of Anthonomus and a bibliography of Rhynchophora.

1907 - Pierce, W. D. Notes on the biology of certain weevils related to the cotton boll weevil. U. S. D. A. Bur. Ent. B. 63(2):39-44.

It is assumed that parasites useful in controlling the cotton boll weevil may be found by studying its nearest relatives. On this account biological and economic notes are given on Anthonomus disjunctus, A. fulnus, A. squaniosus, Lixus musculus, Orthoris crotchii, etc.

1908 - Crawford, J. C. Some new Chalcidoidea. Ent. Soc. Wash. Proc. 9:157-160.

Original descriptions of Cerambycobius cushmani and Catolaccus hunteri, reared from the cotton boll weevil.

1908 - Newell, Wilmon, and R. C. Treherne. A new predaceous enemy of the boll weevil. J. Econ. Ent. 1:244.

Note of the destruction of adult boll weevils by the carabid beetle Evarthrus sodalis Lec. and by another species of Evarthrus.

1908 - Pierce, W. D. The economic bearing of recent studies of the parasites of the cotton boll weevil. J. Econ. Ent. 1:117-122.

Summarization of the work of the Bureau of Entomology in an endeavor to increase the efficiency of parasites of the boll weevil in Texas.

1908 - Pierce, W. D. Factors controlling parasitism with special reference to the cotton boll weevil. J. Econ. Ent. 1:315-323.

Discussion of various factors which affect the abundance and efficiency of parasites in controlling the boll weevil.

1908 - Pierce, W. D. A list of parasites known to attack American Rhynchophora. J. Econ. Ent. 1:380-396.

Contains a list of all parasites known to attack the boll weevil.

1908 - Pierce, W. D. Studies of parasites of the cotton boll weevil. U. S. D. A. Bur. Ent. B. 73, 63 p., Jan. 21.

A report upon extensive studies of the parasites of the boll weevil and other weevils. Contents: Introduction. History. The work on parasites in 1906. I. Examination work: Records prior to 1906; breeding records of 1906; most favorable plant conditions for parasitism of the boll weevil, field conditions, geographical considerations, boll weevil status, boll weevil chronology, conclusions. II. Propagation work: Transfer or artificial propagation of parasites; field work; release of parasites. III. Parasite breeding work: Occurrence of species; geographical and seasonal distribution of parasites; biological notes on the parasites. IV. The source of the parasites: Parasites known to attack Rhynchophora; biologies of the weevils contributing parasites; rotation of hosts. V. Conclusions and prospects. Bibliography. Index.

1909 - Hood, C. E. Types of cages found useful in parasite work. J. Econ. Ent. 2(2): 121-124.

Description of cages used in breeding boll weevil parasites.

1909 - Howell, A. H. Destruction of the cotton boll weevil by birds in winter. U. S. D. A. Bur. Biol. Survey C. 64:5, 1 map.

A continuation of the investigation conducted by the Biological Survey on the food habits of birds in relation to their destruction of the boll weevil. Collections were made of birds found in and about cotton fields in central and northwestern Louisiana during January and February 1908. Six hundred specimens, representing 50 species, were secured, of which 20 species and 81 individuals, or 13.5%, had eaten boll weevils. More birds were feeding upon the weevils and many more weevils were being destroyed by them than in any of the more western localities where birds have been collected at a corresponding season. A record is given of the birds examined which had eaten boll weevils, with brief notes on the status of the more important winter birds. The relatively greater importance of weevil

destruction in winter is mentioned, and emphasis is placed upon the need for rigid protection of each and every species of bird known to feed upon the pest.

1910 - Hunter, W. D. The status of the boll weevil in 1909. U. S. D. A. Bur. Ent. C. 122, 12 p.
The parasites of the weevils are briefly treated.

1910 - Pierce, W. D. On some phases of parasitism displayed by insect enemies of weevils. J. Econ. Ent. 3(5):451-458.
An effort has been made to classify the various examples which have been gathered, to show in how many ways the parasites may interact upon each other, even in as simple a parasite problem as the boll weevil presents. A list of parasites and predators is given.

1911 - Cushman, R. A. Notes on the host plants and parasites of some North American Bruchidae. J. Econ. Ent. 4(6):489-510.
Contains notes on several parasites of the boll weevil which are also parasites of many Bruchidae.

1912 - Pierce, W. D. The insect enemies of the cotton boll weevil. U. S. D. A. Bur. Ent. B. 100, 99 p.
A complete summary of studies on boll weevil parasites and predators, with notes and descriptions.

1912 - Townsend, C. H. T. The cotton square - weevil of Peru and its parasites. J. Econ. Ent. 5(3):252-256.
Lists a number of parasites of Anthonomus vestitus that may be of interest as possible parasites of A. grandis.

1913 - Townsend, C. H. T. Preliminary report of the Picudo of cotton in Peru. J. Econ. Ent. 6(3):303-312.
Contains a list of parasites of Anthonomus vestitus that may be potential parasites of A. grandis.

1914 - Attwater, H. P. Use and value of wild birds to Texas farmers and stockman and fruit and truck growers. Tex. Dept. Agr. B. No. 37, 61 p., 16 fig. May-June. Austin.
The cotton boll weevil is eaten by the plover, killdeer, and other birds. The damage which birds may cause is insignificant compared with the good they do in controlling insect pests.

1914 - Picard, F., and E. Rahand. Sur le parasitisme externe des Bracoides (External parasitism in the family Branconidae). Soc. Ent., B. 8:266-269. Paris, France.
"Of special economic interest is the fact observed that Microbracon mellitor, one of the principal enemies of the cotton boll weevil (A. grandis) in America, is an external parasite of the host."

1914 - Worsham, E. L. The Mexican cotton boll weevil. Ga. State Bd. Ent. B. 39, 24 p., 1 fig., 7 pl. Feb. Atlanta.
Among predaceous insects, ants and ground beetles are effective. The following chalcids are most important parasites: Eurytoma tylodermatis, Microbontomerus anthonomi, Habrocytes piercei, Cateloccus hunteri, and C. incertus.

1916 - Worsham, E. L. Ga. State Bd. Ent. B. 44. Mar. Atlanta.
A list of 53 species of birds which are predaceous on the boll weevil.

1917 - Hunter, W. D. The boll weevil problem, with special reference to means of reducing damage. U. S. D. A. Farmers' B. 848, 40 p.
States that 23 parasites of the boll weevil are known. Twelve species of ants are known to prey on the boll weevil.

1918 - Beal, F. E. L., W. L. McAtee, and E. R. Kalmbach. Common birds of southeastern United States in relation to agriculture. Farmers' B. 755, 43 p. Issued Oct. 1916, Rev. July.
Sixty-six species of birds known to prey on the boll weevil are described; page 4 lists them.

1927 - Krafka, J., and J. E. Miller. Notes on a new fungus of the boll weevil. Ohio Ent. Soc. Amer. Ann. 19(4):464. Columbus.
Resting sporangia of fungus (Pseudolpidium sp.?) of the family Chytridiales were found in the alimentary tract of a dead boll weevil.

1929 - Fenton, F. A., and E. W. Dunnam. Biology of the cotton boll weevil at Florence, S. C. U. S. D. A. Tech. B. 112, 75 p.
The mortality of immature stages of A. grandis caused by parasites was 29.56% in hanging squares and 6.75% in fallen squares in 1925 and 22.7% and 7.84% in 1926, but the greatest mortality in fallen squares was caused by heat (41% and 26%).

1929 - Grossman, E. F. Control of the cotton boll weevil by insect enemies. Science 69(1787):362. Mar. 29.
It is a significant fact that the boll weevil has some 55 insect enemies, including parasites and predators, but of still greater significance is the fact that these enemies are all native species which were present in the cotton belt before the weevil arrived. The boll weevil is attacked by 29 native species of parasites, 20 native species of predators which attack the immature stages, and 6 native species of predators which attack the adults. These particular insects have a large number of native hosts (52 other weevils which in turn attack 91 other species of plants) and are to be found in great abundance in the neighborhood of cotton fields.
Effect of chemical control on parasites and predators: In 13 untreated fields examined in 1926, of a total of 7,046 punctured bolls examined, 1,883 weevils hatched (25.3%) and 399 parasites hatched (5.4%). In 3 treated fields, of a total of 1,405 punctured bolls, 670 weevils hatched (48.7%) and 8 parasites hatched (0.6%).

1930 - Miller, J. H., and G. F. Crisfield. The presence in Georgia of Bracon mellitor, Say., a parasite of the cotton boll weevil. J. Econ. Ent. 23(3):607-608.
Microbracon (Bracon) mellitor, Say., which has been recorded as occurring extensively in Texas and Oklahoma, having the same distribution as the cotton boll weevil appeared in 1929 in cotton fields in all investigated parts of Georgia. When placed in contact with bolls and squares, the female repeatedly attempted to penetrate them with its ovipositor, but was unsuccessful except where it encountered the weevil puncture. An egg is deposited in the cavity beside the weevil larva, and the Braconid larva feeds on the latter.

1931 - Grossman, E. F. Insect enemies of the cotton boll weevil. Fla. Ent. 15(1):8-10.
Investigations in cotton fields in Florida, Georgia, and Alabama, to determine the abundance of insect enemies of Anthonomus grandis Boh., show that the total number of parasites that emerged from 8,451 bolls collected in 1927 was 387, as against 47 from 11,559 bolls collected in 1930. The percentages of squares infested by the boll weevil during the 2 years were 29% and 13.9%, respectively. The yield of the crop, however, was practically the same in both years and ranged from 1/4 to 3/4 bales to the acre.

1933 - Marlatt, C. F. Report of the Chief of the Bureau of Entomology, 1933. Wash., D. C.
Parasitism in Louisiana in 1932 averaged a maximum of less than 10%, of which 90% was due to M. mellitor. Other species reared were the Pteromalids, Catolaccus incertus Ashm., and C. hunteri Cwfd., Eurytoma tylodermatis Ashm., and Eupelmus cyaniceps Ashm.

1935 - Bondy, F. F., and C. F. Rainwater. Boll weevil and miscellaneous cotton insect investigations. S. C. Agr. Expt. Sta. 48:100.

A total of 50,122 boll weevil punctured squares were caged in 1934. From these squares 17 species of Hymenoptera, 13 species of Diptera, and one specie each of Lepidoptera, Heteroptera, Corrodentia, and Neuroptera emerged in addition to boll weevils. Of these species only the following 6 species of hymenoptera are known to be larval parasites of the boll weevil, Microbracon mellitor, Eurytoma tylodermatis, Zatropis incertus, Catolaccus hunteri, Triaspis curculionis, and Microdontomerus anthonomi.

1936 - Folsom, J. W. Observations of Microbracon mellitor (Say) in relation to the boll weevil. J. Econ. Ent. 29(1):111-116.

Observations of Microbracon mellitor Say, the most abundant parasite of Anthonomus grandis Boh., were made in Tallulah, La., in 1934 by means of special rearing cages. The cage is a cardboard cylinder 2 inches high by $3\frac{1}{2}$ inches in diameter, resting in sand in a saucer and covered with a petri dish. A hole in one side is plugged with a cork covered with absorbent cotton on which a mixture of equal parts of honey and distilled water is placed to feed the parasites. These are put in a glass tube which is pushed through a second opening. The tube is then darkened, and the parasites enter the lighter cage. Sound squares into which weevil larvae have been artificially introduced are placed in the cages for oviposition of the parasites.

Oviposition, egg laying, larval growth, spinning (cocoon), larval and pupal development, mating and parthenogensis, longevity, and autumn history of the parasite were studied and reported.

1936 - Smith, G. L. Percentages and causes of mortality of boll weevil stages with the squares. J. Econ. Ent. 29(1):99-105.

During the cotton fruiting seasons 1929-31, inclusive, fallen squares and flared and damaged squares hanging on the plants were collected at about 15-day intervals during June, July, and August from 8 fields representing different soil types in Louisiana. Examination of this material showed the percentage mortalities of all stages of the boll weevil in hanging squares to be 4.3% in 1929, 12.06% in 1930, 9.24% in 1931, and 11.63% in 1932. The corresponding percentages for fallen squares were 11.42%, 41.33%, 15.33%, and 24.08%.

Correlation of the mortalities with data on climatic and other factors showed that the immature stages are affected by climate, predators, parasites, and proliferation. Of these, climate is ordinarily the most important in the case of fallen squares, although of little or no importance in hanging squares.

In both cases, the order of efficiency of the other factors seemed to be parasites, predators, and proliferation. In fallen squares mortality due to predators (mostly ants) amounted to 2% in 1931 and 1932. Mortality caused by parasitism was mainly due to Microbracon mellitor Say. In 1932 parasitism caused 8.22% mortality, or about one-third of the total mortality from all causes.

1936 - Smith, W. R. Consideration of the fire ant Solenopsis xyloni as an important southern pest. J. Econ. Ent. 29(1):120-122.

It often destroys insect pests, such as the immature stages of Anthonomus grandis Boh., but this does not outweigh the injuries it causes.

1938 - Baerg, W. J., D. Isely, and M. W. Sanderson. Entomology. Ark. Agr. Expt. Sta. B. 368:62-66.

The cotton aphis (Aphis gossypii Glov.) becomes of economic importance only on cotton that has received successive applications of calcium arsenate dust for the control of the boll weevil (Anthonomus grandis Boh.) and the cotton leafworm (Alabama argillacea Hbn). The arsenical apparently destroys the Hymenopterous parasites of the aphid and outbreaks of the latter are, therefore, most frequent in late summer.

1940 - Clausen, C. P. Entomaphogous insects, Ed. I, McGraw-Hill, New York and London.

Notes that Hydnocera pubescens Lec. is parasitic on the larvae of the boll weevil.

1943 - Kagan, M. The Arachnida found on cotton in central Texas. Ent. Soc. Amer. Ann. 36(2):257-258.

A list of 36 spiders which were observed to feed on insect pests of cotton in central Texas during 1941-1942. Anthonomus grandis was not attacked.

1943 - Smith, Herbert D. Laboratory rearing of Microbracon vestiticida, Vier., on the bean weevil, with notes on the life history of the parasite. J. Econ. Ent. 36(1):101-104.

Microbracon vestiticida Vier. is a parasite of the Peruvian cotton square weevil, Anthonomus vestitus Boh., and was first imported into the United States in the fall of 1941. After evidence had been obtained that it would attack the boll weevil, A. grandis Boh., in the Southern States, experiments were conducted to find a method of rearing the parasite in considerable numbers in the laboratory.

Ephestia kuehniella Zell. and some coleopterous grain pests were tried as hosts, but the only insect that attracted the parasite was the bean weevil, Acanthoscelides obtectus (Say). Infested beans in mosquito-netting tubes or sacks were the most satisfactory for oviposition.

The egg is deposited externally on the host. The first larva that hatches kills all eggs and weevil larvae that hatch later. Only a few hosts are paralyzed, or stung, by the female. The nonparalyzed host is killed by the young larva in a day or two. A feeding tube is formed extending from the host to the bean skin.

The last complete generation in the experimental series yielded 9.6 progeny per female for the 100 females that were used. By the use of the bean weevil as an alternate host, it is possible to build up the parasite stock during the winter, when immature stages of the boll weevil are not available, so that large releases can be made as soon as the proper stages of the weevil occur in the field early in summer.

1945 - Bissell, T. L. Myiophasia globosa, Tns., Tachinid parasite of the cowpea Curculio. Ent. Soc. Amer. Ann. 38(3):417-440.

Recorded in U. S. parasitizing A. grandis on cotton. Cotton squares punctured by A. grandis were collected by Federal workers in various states at intervals in 1935 and 1936. The tachinid was reared from a small percentage of those collected in Louisiana, Mississippi, Georgia, Florida, and the Carolinas, but not from Virginia or Tennessee. Although well distributed, the parasite is not very important in controlling A. grandis.

1946 - Annand, P. N. Report of the Chief of the Bureau of Entomology and Plant Quarantine, Agr. Res. Admin. 1944-45. U. S. D. A. 1946. Wash.

Investigations in Louisiana showed that the parasite Triaspis vestiticida Vier. and Bracon (Microbracon) vestiticida Vier., which was imported from Peru and released in cotton fields of Texas and Louisiana, would oviposit on larvae of A. grandis in cotton squares and complete their development on them. Both were reared from squares collected in the field after releases were made, but there is no evidence that these parasites survived the winter.

1947 - Berry, P. A. Anthonomus vestitus and its natural enemies in Peru, and their importation into the United States. J. Econ. Ent. 40(6):801-804.

Information on 3 parasites of A. vestitus is provided: Catolaccus townsendi, Triapis vestiticida, and Microbracon vestiticida. The last 2 have been imported into the United States and have been recovered from A. grandis. C. townsendi is present in the United States and is parasitic on A. grandis.

1951 - Gaines, J. C. Beneficial insects' role in cotton insect control. Acco Press, p. 22-24. Mar.

Since the boll weevil egg is deposited inside the square and the grub develops in a protected environment unexposed to the common predators and parasites, the limiting factors to their development are largely environmental. Beneficial insects have not proven so helpful in the control of the weevil as in the case of the other pests.

1954 - Gaines, R. C. Effect on beneficial insects of several insecticides applied for cotton insect control. J. Econ. Ent. 47(3):543-544.

Single applications of the following formulations: 1. dieldrin (1.5%) and DDT (5%) and sulphur (40%), 2. toxaphene (20%) and sulphur (40%), 3. BHC (gamma 3%) and DDT (5%) and sulphur (40%), and 4. BHC (gamma 3%) and DDT (5%) and sulphur (40%) and calcium arsenate made on July 7 greatly reduced the beneficial insect populations. There was a considerable buildup before the next application was required 3 weeks later, on July 28. After the second to fourth application had been made in the regular boll weevil poisoning program, beneficial insect and spider populations were practically eliminated. Beneficial insects included lady beetles, flower bugs, lacewing, Geocoris, assassin bugs, spiders, and syrphids.

1954 - Glick, P. A., and W. B. Lattimore, Jr. The relation of insecticides to insect populations in cotton fields. J. Econ. Ent. 47(4):681-684.

The total population of insects and spiders occurring in experimental cotton fields near Waco, Tex., in 1949 was studied in relation to the use of various insecticide treatments for the control of cotton insects. In general, early applications permitted a greater survival or increase of beneficial forms than later application, while at the same time causing a great reduction in injurious forms.

Toxaphene-sulfur dust applied after 2 early season toxaphene-DDT sprays gave the lowest population of injurious insects and the highest population of beneficial insects.

1955 - Gaines, R. C. Effect on beneficial insects of three insecticide mixtures applied for cotton-insect control in 1954. J. Econ. Ent. 48(4):477-78.

Eight applications were made with 3 dust mixtures--toxaphene plus sulfur, dieldrin plus DDT and sulfur, and BHC plus DDT and sulfur. The results show that after the third application, the beneficial insect and spider populations were practically eliminated from the field.

1956 - Clausen, C. P. Biological control of insect pests. U. S. D. A. Tech. B. 1139:51. June.

A short article on the attempt to introduce Ectatoma tuberculatom (Oliv.) in 1904 and Bracon vestiticida (Vier.) and Triaspis vestiticida (Vier.) in 1941.

1957 - Walker, J. K., Jr. A biological study of Collops balteatus Lec. and Collops vittatus (Say). J. Econ. Ent. 50(4):395-399.

Collops balteatus--Many species of insects were submitted to the larvae for food. In general, they fed on all pupae, insect eggs, and freshly filled adult insects. The pupae of the boll weevil and the pink bollworm (Pectinophora gossypiella Saund.); dead leaf beetles, lady beetles, moths, and grasshoppers; and the eggs of lady beetles, all were readily eaten by balteatus.

The larvae of the pink bollworm and boll weevil were confined with the developing collops. After an initial feeding attack, which would consist of the beetle larvae gnawing a hole in the body wall of the prey, the Collops would withdraw. This behavior was also exhibited when other larvae were submitted to the beetle larvae.

USE OF RESISTANT PLANTS

1903 - Webber, H. J. Improvement of cotton by seed selection. U. S. D. A. Ybk for 1902:384-385.

Remarks on the relative extent of injury by the boll weevil to several varieties of Egyptian cotton.

1904 - Cook, O. F. Evaluation of weevil - Resistance in cotton. Science 20(516):666-670.

Thoughts on the evolutionary history of the relations between the cotton plant in Guatemala and the boll weevil. Changes in plant characteristics, such as the large leafy involucre, hairiness of stems, gelatinization on young bud tissues, and proliferation as they effect weevil attack are discussed.

1905 - Hunter, W. D. The control of the boll weevil, including results of recent investigations. U. S. D. A. Farmers' B. 216, 32 p., 5 fig.

An account of a variety test of cotton.

1906 - Cook, O. F. Weevil resisting adaptations of the cotton plant. U. S. D. A. Bur. Plant Ind. B. 88, 87 p. Jan. 13.

An extensive account of various supposed weevil-resisting characters of cotton.

1907 - Hinds, W. E. Proliferation as a factor in the natural control of the Mexican cotton boll weevil. U. S. D. A. Bur. Ent. B. 59, 45 p., 6 pl.

In 1902 it was noted that the cotton plant has a tendency to protect itself by proliferation of cells at the point of injury by the cotton boll weevil in the squares or bolls. A thorough study of this phenomenon was carried on and statistics collected bearing on the problem of the effectiveness of this tendency of the plant in controlling the pest.

In many varieties of American upland cotton, proliferation takes place in 51% of the cases of weevil attack upon squares and in 55% of those upon bolls. The increased rate of mortality among weevils as a result of this proliferation was found to be 13.5% in squares and 6.3% in bolls. Climatic conditions appear to have little effect upon proliferation, and all varieties of American upland cotton appear to proliferate to about the same extent. The use of fertilizers apparently does not increase proliferation, and the proliferating tissue is not poisonous to the weevils. The author concludes that the weevil larvae are killed mechanically by pressure from the proliferated cells and not from any toxic properties of those cells.

1908 - Bennett, R. L. A method of breeding early cotton to escape boll weevil damage. U. S. D. A. Farmers' B. 314, 28 p. Feb. 7.

Describes practical means of improving cottonseed by plant and seed selection.

1909 - Newell, W., and A. H. Rosenfeld. Report upon variety and fertilizer experiments with cotton in the boll weevil infested sections of Louisiana. La. Crop Pest Comn. 26:65-86.

At Bayou Pierre, 6 cotton varieties were planted March 31 and April 1. On May 11, approximately 58 weevils per acre were found in the plots, and by May 28 the average number of overwintered weevils had increased to 155 per acre. On June 13, 2% of the squares on the plots were infested, as compared with 3.5% to 12% in fields near timber. On July 9, the average number of bolls per plant for the different varieties was as follows:

Hawkins Early Prolific	17.8
Improved Peterkin	15.8
Mehane Triumph	12.4
Seago	11.4
Keno	10.9
"Native"	10.9

On this date an average of 11.33% of the squares and 4.33% of the bolls were infested on the plants. Of the varieties compared, Keno led with 743 lbs. of seed cotton per acre at first picking, August 19 to 29, followed by Hawkins Early Prolific with 702 lbs. These varieties gave a total yield of 1,031 and 911 lbs., respectively.

At Mansura, 2 adult boll weevils were found while planting April 1. On April 23, 23 weevils were found per acre, 109 were found on May 25, and 283 were found on June 2. By June 2, 6% of the squares were infested. On July 18 the bolls per plant were as follows:

Toole Early Prolific	11.6
Hawkins Early Prolific	10.8
Rowden	8.2
King	8.1
Simpkins	8.1
Triumph	6.5
"Native"	6.5

On this date 54% of the squares and 2% of the bolls were infested. The first open boll was found in Toole Early Prolific. In total yield, as well as in yield at the first picking, Hawkins Early Prolific ranked first with 563 and 212 lbs. of seed cotton per acre, respectively. Toole Early Prolific ranged next in total yield and Mehane Triumph in earliness. The results of other variety tests are briefly reported.

In the fertilizer test on the rich alluvial soil at Bayou Pierre, the results varied considerably, but nitrate of soda apparently increased the crop wherever used. At Mansura, on dark rather sandy loam, the nitrate was not so effective. The excessive weevil infestation prevented the utilization of the fertilizer applied.

The obstacles in the way of late planting to avoid the weevil injury are pointed out, and the results obtained in experiments are briefly summarized.

1911 - Cook, O. F. Relation of drought to weevil resistance in cotton. U. S. D. A. Bur. Plant Ind. B. 220, 27 p.

Weevil resistance characters of cotton are more effective in dry regions or seasons. Under these growing conditions the same factor that restricts the growth of the plant also tends to prevent the propagation of the weevils. In humid regions, wet or cloudy weather may impede plant growth but does not weevil propagation.

Weevil resistant characteristics, such as earliness, quick fruiting, and determinate habits of growth are likely to diminish or disappear when plants grow under intense conditions of heat or humidity.

Effects of cultural methods and variety characteristics on weevil propagation under arid and humid conditions are discussed.

1911 - Hunter, W. D. The boll weevil problem with special reference to means of reducing damage. U. S. D. A. Farmers' B. 344:25-26. Sept.

The author lists 7 varieties which will produce an early crop and have been of value in weevil infested regions.

1912 - Anonymous. Mexican boll weevil. Sen. Doc. 305:132-136.

Cotton plant characteristics, such as proliferation, early bearing, determinate growth, hairy stalks and stems, abundance of secretion nectaries, pendent bolls, involucral bracts, thickwalled bolls and tendency to retain infested fruit, and their effect on minimizing weevil populations are discussed.

1912 - Cook, O. F. Cotton improvement under weevil conditions. U. S. D. A. Farmers' B. 501, 22 p. June 11.

Explains how profitable yields of cotton can be maintained by better selection of varieties, improved culture, and better markets.

1912 - Hunter, W. D. The boll weevil problem with special reference to means of reducing damage. U. S. D. A. Farmers' B. 512:26. Oct.

Emphasizes the need to plant early maturing varieties to insure an early crop. Seven early varieties are recommended.

1912 - Hunter, W. D., and W. D. Pierce. The Mexican cotton boll weevil: A summary of the investigation of this insect up to December 31, 1911. U. S. D. A. Bur. Ent. B. 114.

The authors discuss plant characteristics, such as proliferation, early bearing, determinate growth, hairy stalks and stems, abundance of secretion from nectaries, pendent bolls, involucral bracts grown together at base, and thick-walled bolls and tendency to retain infested fruit, all of which affect weevils adversely.

1917 - Hunter, W. D. The boll weevil problem with special reference to means of reducing damage. U. S. D. A. Farmers' B. 848:25-26. Aug.

Sixteen early maturing cotton varieties are named.

1917 - Lewis, A. C., and C. A. McLendon. Cotton variety tests for boll weevil and wilt conditions in Georgia. Ga. State Bd. Ent. B. 46:34. Jan. Atlanta.

Much information useful to cotton growers as to varieties of cotton which are most resistant to the boll weevil and wilt disease. Tables show results of different varieties.

The weevils begin to emerge early in the spring and feed first on the buds of the cotton and later on the squares. The buds that become blackened after the attack should be picked off, as well as the squares that become yellow, while those that fall to the ground should be collected and burned once a week until about the middle of July. As a rule, until August the boll weevil is not sufficiently numerous in the field to destroy all the squares that appear. In the absence of sufficient squares, the matured bolls are attacked; hence, the necessity for selecting a variety that will continue to fruit until late in the season.

1919 - Lewis, A. C., and C. A. McLendon. Cotton variety tests, 1918. Ga. State Bd. Ent. B. 52, 38 p., 1 fig. Jan. Atlanta.

Describes in detail the results of 9 tests made with varieties of cotton exhibiting earliness and, therefore, adaptation to escape attacks of the cotton boll weevil and resistance to wilt disease and anthracnose.

1920 - Lewis, A. C., and C. A. McLendon. Cotton variety tests, 1919. Ga. State Bd. Ent. C. 29, 9 p. Jan. Atlanta.

The results of a series of cotton variety tests are summarized and from them are drawn recommendations as to the varieties of cotton that can be most successfully grown under present boll weevil and disease conditions in Georgia.

The ideal cotton plant to grow when the cotton weevil is present should begin fruiting close to the ground, early in the season, and have long fruiting branches, at the base, that continue to grow throughout the season. Under boll weevil conditions the more cotton that is produced on the lower half of the plant, the larger will be the yield per acre.

A. grandis is now present in the greater part of Georgia, and it is important to grow a variety of cotton adapted to the soil and climate and to keep the best improved seed of that variety. If an individual does not improve his own cottonseed by careful selection, it will pay him to buy improved seed from someone who does.

1922 - Hunter, W. D. The boll weevil problem. U. S. D. A. Farmers' B. 1263:21-22. Feb.

The value of producing an early crop to minimize weevil damage. Thirteen early maturing cotton varieties are listed.

1925 - Ware, J. O. Cotton variety experiments. Ark. Agri. Expt. Sta. B. 197.
Tests conducted in 4 sections of Arkansas. To obtain high production under boll weevil conditions, earliness is necessary. The first picking is a direct measure of earliness. Table summaries show the relation of the average of the check variety (in all cases early varieties) with the other varieties.

1925 - Ballard, W. W. Behavior of cotton planted at different dates in weevil control--Experiments in Texas and South Carolina. U. S. D. A. Dept. B. 1320, 43 p. Apr.
Information on plant growth characteristics during the growing season, as related to the ability of the weevil to attack the plant. Experiments were conducted at 3 widely separated parts of the cotton belt to secure comparative data on plant development under different soil and climatic conditions. Information was obtained on the effect of planting data, square formation, flowering, and shedding. Lone star variety was used in these tests.

1927 - Cook, O.F., and C.B. Doyle. Sea-Island and Meade cotton in the Southeastern States. U. S. D. A. Dept. C. 414, 19 p., 7 ref. May.
Sea Island Cotton has a greater susceptibility to boll weevil injury due to thinner walls and softer texture of the bolls and also because it requires a longer season to mature a full crop. The use of Meade cotton when grown from pure seed, as a substitute variety, is discussed. In pure stands, fiber was equal in length and quality to sea island and, under weevil conditions, distinctly larger crops could be obtained.

1927 - Isely, D. Ark. Agr. Expt. Sta. 39th Ann. Rpt. B. 221:34. Aug.
Relation of abundance of boll weevil to color and size of leaf was studied in 1925-1926. Preference for green leaf cotton over red leaf was demonstrated. After green leaf had become crowded for food, weevils would migrate to red leaf cotton.

1928 - Isely, D. The relation of leaf color and leaf size to boll weevil infestation. J. Econ. Ent. 21(4):553-559.
Field experiments in 1925 and 1926 indicate a marked preference on the part of the boll weevil for green foliage as compared with red. No economic importance can at present be attached, however, to the apparent immunity of red-leafed cotton, as there is no red-leafed variety that can yet be recommended for commercial planting. Negative results were secured in experiments to determine any preference shown by A. grandis between large and small leafed varieties, this character having hitherto been taken into consideration by some plant breeders. Provided the size and vigor of the plants was about equal, no apparent choice was shown between different leaf sizes.

1933 - Calhoun, P. W. Irregularity among cotton plants in time of fruiting as a factor affecting susceptibility to damage by the cotton boll weevil. J. Econ. Ent. 26(6):1125-1128.
Considerable irregularity seems to exist among cotton plants as regards earliness of fruiting. Using the time of appearance of the first blossom on each plant as the criterion, the frequency distribution for 600 plants approximated a normal curve, the maximum for the frequency histogram occurring on the 11th day. Such lack of uniformity in time of fruiting perhaps contributes to increased susceptibility of cotton to damage by the boll weevil.

1934 - Isely, D. Relationship between early varieties of cotton and boll weevil injury. J. Econ. Ent. 27(4):762-766.
The varieties of cotton were evaluated in 1926, 1927, and 1929; (1) Trice (early), (2) Acala (medium early), and (3) Snowflake (late). Rowden was substituted for Snowflake in 1927. Although none of the experiments represented conditions of extreme weevil injury, the early variety suffered the least weevil injury and produced the best yield.

1939 - Hixson, E. Science serving agriculture - insect pest studies. Report of Okla. Agr. Expt. Sta., 1936-38:94-95. Jan.

Studies on the use of high yielding varieties of cotton in combating the boll weevil.

1941 - Rainey, R. C. Relation of developing boll of susceptibility to insects. Empire Cotton Growing Corp. Rpt. Expt. Stas. 1939-1940:39-46.

Although the boll weevil is not mentioned, the author discusses biochemical factors influencing the changes in susceptibility to insect attack which occur in the course of boll development. It is pointed out, however, that while the results obtained may suggest a relationship, they do not prove their existence.

1951 - Painter, R. H. Insect resistance in crop plants. The MacMillan Company, N. Y., 1951:309-314.

A number of cotton plant characteristics are discussed, including earliness, proliferation, fruiting rate, rate of boll growth, plant color, and odors that have been shown to limit the ability of the boll weevil to attack the cotton plant.

1951 - Stephens, S. G. Sources of resistance of cotton strains to the boll weevil and their possible utilization. J. Econ. Ent. 50(5):415-417.

The purpose of this paper is a consideration of the possibilities of synthesizing genetic resistance to the boll weevil. A suggestion for an appropriate procedure is given. Such factors as host specificity, plant preference, plant color, plant hairiness, and influence of stem glands are discussed. The following program was initiated at Raleigh, North Carolina. Objectives of this study were:

(a) To evaluate and measure preferences associated with specific plant characteristics.

(b) To study the effect of the composition of a plant population on the degree of preference expressed.

(c) To investigate the possibility of increasing resistance by combining different sources of preference.

1951 - Wannamaker, W. K., W. H. Wessling, and S. G. Stephens. Boll weevil resistant cotton. Res. & Farming (N. C. Agr. Expt. Sta.) 15(1):14.

Two years of experiments have shown that 2 different types of hairy cotton, known as "Pilose" and "MU-8," are less damaged by weevils than standard commercial varieties of upland cotton. The difference runs from 10% to 30%.

These studies are only of a preliminary nature, and the resistant types presently available fall far short of the standard requirements of yield and fiber properties in an economic variety.

1951 - Wannamaker, W. K. The effect of plant hairiness of cotton strains on boll weevil attack. J. Econ. Ent. 50(4):418-423.

A study was initiated on the possibility of using hairy types of upland cottons as a source of resistance to the boll weevil. Collections were made of upland cottons representative of the available hairy types. F_1 hybrids were made between Pilose (H_2H_2) and other hairy types.

The parental types and F_1 hybrids were planted in a randomized block experiment in the spring of 1955. The experimental field was artificially infested with boll weevils. The principal results of this experiment may be summarized as follows:

1. MU-8 and Pilose which carried the homozygous major factors for hairiness, H_1 and H_2 respectively, received significantly less boll weevil damage than the other types included in the experiment.
2. Since MU-8 and Pilose carry intensifying genes for hairiness, in addition to the major factor, resistance is not due entirely to the genes H_1 and H_2 but more likely to the presence of the major factor supplemented by certain unknown intensifiers.
3. Differences in the positions and characteristics of hairs are discussed in relation to their possible importance in boll weevil resistance.

1958 - Wessling, W. H. Genotypic reactions to boll weevil attack in upland cotton. J. Econ. Ent. 51(4):508-512.

Mutant lines of Upland cotton carrying any 2 of 4 mutant genes--H_1, H_2, gl, and R_1,--which promised to confer a certain degree of resistance to attack by boll weevil, were tested together with lines having the same genetic background but differing by opposite alleles to the genes under test. All mutant lines showed varying degrees of resistance to boll weevil attack; the lines combining H_1 and H_2 to the highest degree, those combining gl and H_2, and gl and H_1, ranking second and third. Lines carrying the genes R_1 in combination with gl or H_2 were tested in a separate experiment. Both strains showed a relatively high degree of resistance. The main effects of the mutant genes H_1, H_2, and gl, could only be estimated on the assumption that their interactions were unimportant. On this basis the data obtained in the experiments indicate that H_2 contributed more to resistance than H_1 while gl had no significant effect.

1958 - Wessling, W. H. Resistance to boll weevil in mixed populations of resistant and susceptible cotton plants. J. Econ. Ent. 51(4):502-506.

The reliability of resistance to attack by the boll weevil, conferred by the mutant gene, H_2, was tested under different environmental conditions; that is, in different proportions of the mutant strain, Pilose, and the susceptible variety, All-In-One, or in the absence of susceptible plants.

In order to carry out this test it was necessary to isolate individual plots from one another, using corn as a barrier crop, and to provide a uniform infestation of boll weevils. This method proved satisfactory. The degree of resistance was measured inversely by the proportion of squares with egg-laying punctures. The mutant strain, Pilose, showed a significantly lower proportion of egg-laying punctures throughout the investigation. A slight but consistent increase in number of egg-laying punctures, with increase in the number of susceptible plants in the mixture, was noted in the resistant strain, Pilose, as well as in the susceptible variety, All-In-One.

CONTROL - EQUIPMENT

1920 - Johnson, E., and B. R. Coad. Dusting machinery for cotton boll weevil control. U. S. D. A. Farmers' B. 1098, 31 p. Jan.

Considered only as a progress report, and issued solely for the purpose of recording the information on the dusting machinery that has been secured up to 1920. The special factors governing the construction of the cotton-dusting machine include the type of labor available, the areas to be treated in the field, field conditions, the necessity for night operation, the characteristics of poison utilized, and the type of dust cloud required. The recommendations given in this paper are not, however, considered in any way final, and it is expected that improvements will be developed from time to time for years to come.

1921 - Coad, B. R. Killing boll weevils with poison dust. U. S. D. A. Ybk 1920-21:241-252, 2 fig.

Details of suitable machinery for dusting.

1924 - Coad, B. R., E. Johnson, and G. L. McNeil. Dusting cotton from aeroplanes. U. S. D. A. Dept. B. 1204, 40 p., 19 fig.

A method of releasing insecticide dust from aeroplanes was adapted in tests against Alabama argillacea Hb. and, to a certain extent, against Anthonomus grandis. The tests described did not, by any means, determine the practicability of using this means of applying insecticides, but they showed that the dust can be blown onto plants from the air and can be made to adhere to the plants under daytime conditions. Alabama argillacea was successfully controlled with much less poison than is necessary with ordinary dusting machines, and, though a more thorough application would be necessary to control A. grandis, indications are

that the aeroplane might be used with advantage against this insect, also. Financially, the method would seem to be more economical than the use of ground machines and would, of course, be employed by communities, cooperatively.

1924 - Post, G. B. Boll weevil control by airplane. Ga. State Col. of Agr., Ext. Div. B. 301, v. 13(4):22. Nov.
Discusses advantages, feasibility, and principles of applying calcium arsenate dust by airplane for boll weevil control.

1925 - Hinds, W. E. Airplane dusting. La. Agr. Expt. Sta. Ann. Rpt. of La. State U. and A. & M. Col.
The application of calcium arsenate to cotton for weevil control by means of airplanes was undertaken in a commercial way and upon a large scale in Louisiana for the first time in 1925. The Huff-Daland Dusters Inc. was the only concern in the field. This work was closely watched from the experimental standpoint, also. With 4 airplane dusting units at work, more than 50,000 acre-applications were made to cotton for weevil control. There did seem to be an excellent prospect in Louisiana for the expansion of airplane dusting for boll weevil control.

1926 - Hinds, W. E. Airplane dusting for cotton for boll weevil control. J. Econ. Ent. 19(4):607.
In this paper, of which only the abstract is published, the method adopted for dusting cotton by means of aeroplanes is described. An aeroplane adapted for this work carried a load of 500 lbs. of calcium arsenate, and was flown to and fro across the fields at a height of from 10 to 25 ft., so that the dust cloud covered a strip of cotton from 200 to 250 feet wide, the aeroplane travelling at 100 miles per hour and dusting an acre of cotton in less than 2 seconds. One aeroplane can protect 5,000 acres of cotton through the season. Planters can cooperate in the use of such an aeroplane which relieves them from disagreeable night work. The aeroplanes can dust in daylight, in spite of light breezes, and can give prompt protection after heavy rains and to the rankest growth of cotton. The results of their use against the boll weevils were very satisfactory.

1926 - Wilson, R. J. Boll weevil control by airplane. Agriculture--An attractive field for commercial aviation. Cong. Rec. 67(40):2887-2888. Wash.
During 1924 a commercial corporation successfully dusted about 1,000 acres of cotton with calcium arsenate from airplanes for the control of the boll weevil in Mississippi. In 1925 the activities of the company were extended, and 50,000 acres of cotton, 200,000 peach trees, pecan groves, and sugarcane fields were dusted in several States, the work gaining the unqualified approval of 98% of the farmers concerned. The inclusive cost of dusting cotton was about \$5.35 an acre, 3 applications being made.

1929 - Thomas, F. L., W. L. Owen, Jr., J. C. Gaines, and F. Sherman III. Boll weevil control by airplane dusting. Tex. Agr. Expt. Sta. B. 394, 40 p., 11 fig. Apr. College Station.
The use of airplanes for the distribution of calcium arsenate on cotton is briefly reviewed. In Texas, the area so treated has increased from 3,000 acres in 1925 to approximately 50,000 acres in 1928. This bulletin describes, in detail, observations of this method against the boll weevil on 3 farms, containing 400, 1,200, and 2,700 acres of cotton, respectively. Three to 5 applications were made, the amount used being always more than 5 and sometimes $8\frac{1}{2}$ lbs. to the acre. Within 10 days, after 2 applications had been made, the number of squares punctured by the weevils was reduced by 50% and increased yields of seed cotton, varying from 63 to 206 lbs. to the acre, were produced wherever conditions warranted the use of control measures.
The cost of dusting by airplane, including the poison, ranges from \$0.75 to \$1.00 an acre, and the method is considered justifiable when infestation averages 15% early in the season or 20% later on, with weather conditions favorable to the weevils. Airplane dusting is particularly suitable where wet ground prevents the

usual dusting at 5-day intervals. The price of the cotton must be high to justify the expense. As a rule, small detached areas cannot be dusted by airplane so profitably as large ones. Detailed information and recommendations are included.

1929 - Marlatt, C. L. Report of the Chief of the Bureau of Entomology and Plant Quarantine (1928-29) U.S.D.A. p. 39. Washington.

In connection with the control of the boll weevil, a number of dusting machines have appeared on the market that expel a large quantity of dust and allow it to drift across the field, so that swaths of from 300 to 500 ft. can be treated. Careful tests of such dust clouds showed that a large quantity of dust was wasted owing to an overdosage close to the machine and an irregular, inefficient dosage over the remainder of the area.

1930 - Sherman, F. Results of airplane dusting in the control of cotton boll worm (Heliothis obsoleta Fab.). J. Econ. Ent. 23(5):810-811.

Large-scale airplane dusting operations near College Station, Tex., in 1927, indicated that the boll weevil might be successfully controlled on cotton by use of 5 to 6 lbs. of calcium arsenate to the acre.

1934 - Gaines, R. C., and D. A. Isely. Machinery for dusting cotton. U. S. D. A. Farmers' B. 1729, 14 p., 10 fig.

In this bulletin, which supersedes a previous one, brief descriptions are given of various types of machines (showing their adaptability to different requirements) for use in the United States in applying calcium arsenate dust to cotton against the boll weevil. The chief advantage that aeroplanes have over ground machinery is that they render possible the treatment of fields immediately after heavy or prolonged rains, when the weevils may be causing serious damage. Experience has proved that their use is not more costly.

1951 - Miller, H. F., and J. C. Gaines. Size of spray nozzle in relation to cotton insect control. Tex. Agr. Expt. Sta. Prog. Rpt. 1312. Jan. 18.

The tests consisted of 3 treatments: (1) hollow cone nozzle (1.8 gal. per acre), (2) hollow cone nozzle (5.4 gal. per acre), and (3) hollow cone nozzle (13.5 gal. per acre). One, 2, and 3 nozzles per row were used on the 1st and 2d, 3d, and 4th to 10th applications, respectively. Effective control of the boll weevil and other cotton insects was obtained at each rate, as long as the proper amount of toxaphene and toxaphene-DDT spray was applied. The lower rates were more economical.

1952 - Fife, L. C., R. L. Walker, and C. E. Jernigan. Low volume of spray reduces cost of boll weevil control. S. C. Agr. Expt. Sta. Ann. Rpt. 64:92-93.

As the time and labor required to handle excessive amounts of water make spraying expensive, tests were conducted with emulsion sprays of various insecticides to determine the smallest volume of spray per acre required to give adequate control of the boll weevil.

In 1950-51 toxaphene emulsion spray was applied with different sizes of hollow-cone-type nozzles to obtain a range of 1.9 to 11.4 gal. per acre. All treatments gave equally effective control of the boll weevil.

1955 - Smith, H. P., and R. L. Hanna. Effects of the type and arrangement of spray nozzle on the control of the cotton bollworm and boll weevil. Tex. Agr. Expt. Sta. Prog. Rpt. 1752. Feb. 13.

Tests were conducted during 1952-54 at College Station to determine the best type and arrangement of spray nozzle for applying insecticides for the control of the cotton bollworm and boll weevil. Spray nozzles producing a hollow-cone spray pattern resulted in higher yields than spray nozzles producing a flat fan-shaped spray pattern. Sprayed plots yielded approximately half a bale more cotton per acre than unsprayed plots. One hollow-cone type spray nozzle, spraying directly over the row, resulted in yields equal to those from 2 and 3 hollow-cone spray nozzles spraying the top and sides of the drill row of cotton plants.

1956 - Anonymous. Handbook on aerial application in agriculture. College Station, Tex. Dec.

A compilation of information resulting from research and conferences conducted by the Texas Engineering Experiment Station, the Texas Agricultural Experiment Station, and the Texas Agricultural Extension Service. The handbook contains data on aerial applications to control the boll weevil and other cotton insects.

1956 - Smith, H. P., C. M. Hohn, and R. L. Hanna. Effects of spray nozzle types and arrangements on cotton insect control. Tex. Agr. Expt. Sta. Prog. Rpt. 1906. Nov. 19.

Tests on the use of spray nozzle types and arrangements conducted in 1955 and 1956 at the Brazos River Valley Laboratory continue to favor an arrangement of 1 cone nozzle per row.

There was no significant difference in yield in the 1955-1956 tests due to nozzle types or arrangements. Equal control can be obtained with simple one-nozzle-per-row arrangements as with more costly and complex arrangements.

1959 - Adkisson, Perry L., L. H. Wilkes, and B. J. Cochran. Relative efficiencies of certain spray nozzles for cotton insect control. J. Econ. Ent. 52(5):985-991.

Two conventional cone-type spray nozzles were compared with 3 kinds of wideswath, jet-type nozzles for effectiveness in controlling the boll weevil and the bollworm, Heliothis zea (Boddie). The wideswath nozzles were capable of spraying 6 to 12 rows per nozzle. Tests were arranged in randomized replicated small plots and were conducted under irrigated and dry land conditions. Three rates of application per acre were used.

Results indicated that the conventional cone-type nozzles produced significantly better control of the boll weevil than the wideswath nozzles. They also were slightly more effective for controlling the bollworm. All treated plots produced significantly higher yields than the untreated check. However, the highest yields were harvested from the plots sprayed with the conventional cone-type nozzles.

Card data collected for droplet size indicated that the wideswath nozzles produced larger droplets and decreased plant coverage with an increase in distance from the nozzle. Weevil mortality records and yield data indicated that this larger droplet size was mainly responsible for the inferior performance of the wide-swath nozzles when compared with the cone nozzles.

1959 - Wilkes, L. H., P. L. Adkisson, and B. J. Cochran. Effect of spray nozzle types on cotton insect control. Tex. Agr. Expt. Sta. Prog. Rpt. 2078. Mar. 1, 1959.

In experiments conducted in 1958 near College Station, conventional low gallonage, boomtype nozzles gave better insect control and produced higher yields of seed cotton than 3 types of wideswath or boomless nozzles which covered 6 or 12 rows per nozzle.

CONTROL - IN GIN MILLS

1905 - Hunter, W. D. Controlling boll weevil in cotton seed and at Ginneries. U. S. D. A. Farmers' B. 209:31.

The author carried on experiments to determine whether it is possible to prevent the dissemination of this pest through the agency of cotton gins. When weevils were passed through the main fan in a pneumatic elevator system with a rate of 1,800 revolutions per minute, all the weevils were destroyed. When weevils were fed into the outer roll of a gin revolving at the rate of 400 revolutions per minute, 92.4% came through alive. In these experiments it was found that weevils may escape with the seed into the seed chute and also at the mote board. Also, weevils may pass through cleaning feeders without being injured.

An account is given of the present system of handling and ginning seed cotton in various localities. As a result of the author's observations and experiments it

was recommended that a separate seed-cotton storage house be maintained and be provided with special cleaners which may be of use in removing weevils and facilitating ginning. It is also recommended that in the gin house proper cleaner feeders and cotton cleaners be used more extensively and that all trash be treated so as to effectively destroy the weevils.

CONTROL - DILUENTS

1948 - Gaines, J. C., and R. L. Hanna. Comparison of diluents in insecticide mixtures for cotton insect control. J. Econ. Ent. 41(5):811-812.

Pyrophyllite and sulfur were used as diluents in mixtures with BHC, DDT, a chlorinated camphene, and calcium arsenate. Benzene hexachloride-DDT mixtures, chlorinated camphene, and calcium arsenate mixtures were equally effective against the boll weevil and gave significantly better control than the diluents alone. Pyrophyllite or sulphur did not affect the toxicity of these insecticides when used against the boll weevil. Sulfur prevented red spider increases.

The benzene hexachloride-DDT and the chlorinated camphene both gave significantly better yields than calcium arsenate. The use of different diluents did not affect the yields.

CONTROL - FUMIGATION

1905 - Hunter, W. D. Controlling the boll weevil in cotton seed and at ginneries. U. S. D. A. Farmers' Bul. 209, 31 p., fig. 1.

It was found that hydrocyanic-acid gas, when used at twice as great a strength as required for the fumigation of grain, failed to kill the boll weevils after 5 hrs. exposure at a depth of 6 to 10 inches in cottonseed. Similar results were obtained when house flies were placed at depths of from 6 to 12 inches in cottonseed. Carbon bisulphide was used at the rate of from $1\frac{1}{2}$ to 10 lbs. per 1,000 cu. ft. It penetrated and killed the boll weevils to a depth of $4\frac{1}{2}$ ft. in cottonseed.

The slow rate of penetration indicated the futility of using carbon bisulphide in this form. Experiments were, therefore, tried in applying carbon bisulphide in an artificially volatilized form according to a method devised by W. E. Hinds. A current of air was passed through liquid carbon bisulphide and the resulting vapor was then driven by pressure through the cottonseed to the bottom of the containing cylinder. Diffusion of the vapor under pressure was complete and rapid. In this manner it was possible to kill boll weevils when the carbon bisulphide was used at the rate of 8 lbs. per 1,000 cubic feet of space for a period of 40 hours.

1915 - Hinds, W. E. Fumigation method for sacked cotton seed. J. Econ. Ent. 8(4):400-402.

The method of fumigation--carbon bisulphide against the cotton boll weevil--described in this paper was worked out in Alabama and is extensively used in the treatment of cottonseed grown for planting purposes. With this method 4 men can treat 600 or more sacks per day. The apparatus consists of a 3-in. air pump with which the liquid and vapor can be forced through the seed. This is connected by pressure tubing with one branch of an ordinary 1/4-in. Y such as is used in spraying work. On this branch is a cutoff and a regular spraying accessory; on the other is a cutoff and an indicator to measure the amount required for each sack. The Y is connected with tubing to penetrate the seed. The tubing is perforated for the last 18 inches to form a spray. About one ounce of carbon bisulphide is needed for a 3-bushel sack.

1924 - Marcovitch, S. New insecticide for the Mexican bean beetle and other insects. Tenn. Agr. Expt. Sta. B. 131, 19 p., 7 fig. Oct. Knoxville.

Mustard gas (di-chloroethyl sulphide) and sodium fluosilicate nitrobenzene were not outstanding in their effectiveness against A. grandis.

1925 - Mackie, F. P. Boll weevil in cotton. Bombay Bact. Lab. Rpt. 1924:30-31. Bombay.

Tests were made with hydrocyanic acid gas, with a view to fumigating American cotton to prevent the introduction of the boll weevil into India. In the absence of this species, various native weevils were used in these tests, including Calandra, which proved the most resistant. The time of exposure appeared to be of greater importance than the concentration of the gas. All individuals of this weevil were killed after exposures for 19 hours or more to a gas concentration evolved from $\frac{1}{2}$ oz. each of sodium cyanide and sulphuric acid, whereas concentrations obtained with 1 oz. of each had no effect even after 6 hours.

With formaldehyde vapor all the weevils were killed in 4 hours by a concentration of 10 parts per 100,000 or in 2 hours by 20 parts per 100,000.

A few experiments to test the absorption of hydrocyanic acid by various substances indicate that liquid paraffin does not absorb the gas but that cotton and kerosene do.

1926 - Jacobsen, W. C. Bureau of Plant Quarantine and Pest Control. Calif. Dept. Agr. Mo. B. 14, 7-12:146-172, 3 fig. Sacramento.

"The work of the bureau on vacuum fumigation is reported on by D. Mackie. Shipments to the extent of 20,000 citrus trees have been successfully fumigated with liquid hydrocyanic acid gas. This process may also be substituted for the usual practice of steaming railway wagons; it is safer and more convenient. Used at the rate of 1 oz. of liquid gas to 100 cu. ft., all boll weevils were killed. Successful experiments were also made with 2 oz. sodium cyanide solution to 100 cu. ft."

1927 - Turner, A. J., and D. L. Sen. The use of hydrocyanic acid gas for the fumigation of American cotton on import into India. Agr. J. 22(3):173-175. May. Calcutta.

A short account of the results of experiments with hydrocyanic acid gas for fumigating cotton bales against Anthonomus grandis as a precaution against its importation into India from America, the full details of which are to be published later. The work in India was confined to Calandra (Sitophilus) oryzae L. (grain weevil) but it was subsequently arranged with the American authorities to repeat the work using A. grandis.

The conclusion is drawn that under Bombay conditions the weevils would be exterminated by an exposure for 4 hours to a concentration of 450 parts HCN per 100,000 by volume or for 20 hours to a concentration of 150 per 100,000 (calculated at normal pressure and temperature). For practical purposes it is best to combine a short period (6 hours) at a high concentration with a long period (additional 14 hours) at a lower concentration. The minimum initial concentration for the second period should be 200 parts HCN per 100,000.

Fumigation can be satisfactorily carried out on a large scale in barges, when these are sound and the bales are both dry and also compressed to a high density, 1 pound of sodium cyanide being sufficient for about 5 bales of cotton. These results have led the Government of India to issue a notification under the Destructive Insects and Pests Act. Though cotton does absorb hydrocyanic acid gas, it is fairly rapidly and completely discharged, and there is no evidence of the occurrence of any irreversible chemical combinations.

CONTROL - GENERAL

1895 - Howard, L. O. The new cotton boll weevil. Insect Life, Div. Ent., U. S. D. A. 7: 281. Mar.

Regarding the importance of the pest, and the investigation started by the sending of Mr. C. H. T. Townsend to Texas in December 1894. The Assistant Secretary of Agriculture reported the seriousness of the outlook to the governor of Texas, and urged the importance of immediate legislation to provide for quarantining and remedial work.

1895 - Howard, L. O. The Mexican cotton boll weevil. U. S. D. A. Bur. Ent. C. 6(2):5, fig. 1-2. Apr.

The results, substantially, of Mr. Townsend's field investigations of the insect in Mexico and Texas. It is pointed out that time has not offered opportunity to conduct extensive tests with remedies, and the suggestions made in this direction are largely from the theoretical side. The impracticability of the use of poisons is shown. The collection and destruction of infested bolls and rotation of crops are suggested.

1901 - Rangel, A. F. Estudios preliminaries acerca picudo del algodon (Insanthonomus grandis I. C. Cu.). Comn. Parasit. Agr. B. 1(3):93-104. Mex.

Contains remarks on previous work, importance of the insect, origin and transportation, biology, character of injury, and action of climate on the image. Burial of weevils is indicated as futile. Remedies mentioned include: proper soil preparation, destruction of stalks, inundation, selection of seed, destruction of fallen squares, insecticides, and traps.

1901 - Mally, F. W. A preliminary report of the progress of an investigation concerning the life history, habits, injuries, and methods for destroying the Mexican cotton boll weevil (Anthonomus grandis). Authorized by a Special Act of the 26th Legislature of Texas, p. 1-33, Suppl., p. 35-45, State Printer. Austin.

Remedial measures are discussed at length. These include: the use of early maturing varieties of cotton and other cultural remedies, grazing of cotton in the fall, trapping weevils in spring and fall, fall plowing, hand picking of infested squares, and the use of arsenate of lead as a spray. The question of spraying and spray machinery is given lengthy treatment. The futility of the use of lights for trapping the weevil is pointed out.

1901 - Mally, F. W. The Mexican cotton boll weevil. U. S. D. A. Farmers' B. 130, 29 p.

Lists several means of weevil extermination by cultural means and chemical spraying.

1902 - Madero, J. M. C. Una plaga del algodon. Agricultura B. 2(14):483-485. July 15. Salvador.

Comments on failure of means of control as then recommended by the U. S. D. A. Cotton growing has been abandoned on account of the weevil in Coahuila, and replaced by corn and wheat.

1903 - Anonymous. The boll weevil reward. Tex. Stockman & Farmer 22(39):2. Aug. 12.

A copy of the act by which the sum of $50,000 was set apart as a reward for a practical remedy for the boll weevil.

1904 - Anonymous. Boll weevil in North Texas. Farm & Ranch 22:8. Apr. 23.

A plea for the eradication of the weevil when found in isolated colonies in northern Texas. An account of the methods used to eradicate the weevil in Sabine and Orleans parishes in Louisiana.

1905 - Hunter, W. D. The status of the Mexican cotton boll weevil in 1903. U. S. D. A. Ybk. 1903:205-214, 5 pl., 1 fig.

A brief account of the distribution, depredation, life history, and means of controlling this pest.

The author believes that no direct insecticide methods, such as the use of poisons, will be effective in destroying the pest. Neither is any hope entertained of great help from the use of fungus diseases or resistant varieties of cotton. Apparently the greatest reliance must be placed in proper cultural methods, such as the early destruction of plants in the fall and hastening the maturity of the crop in order to avoid the attacks of the weevils.

1906 - Anonymous. El picudo del algodon. El Progreso de Mex. 12:64, 74-75, 88-89, 99-101, 115-117, 131-132. Jan. 30 - Mar. 8.

A brief outline of the work carried out by the Comision de Parasitologia during 1905, and the plan of work for 1906. The various methods of control are discussed at length. These include the seed to be used, method of preparing the soil, planting, cultivating, using trap plants, shaking the weevils from the plants, using special machines, the breeding and distributing a native ant--the kelep or Guatemalan ant--using poisons, planting of special varieties of cotton and various ideas regarding weevil control. New projects to be undertaken by the Commision are mentioned.

1908 - Newell, W. The boll weevil. La. State Crop Pest Comn., 2d Bien. Rpt. of the Sec. 1906-1907:9-16 and an appendix.

The following topics are discussed: Cultural experiments, autumn spraying experiments, weevil destroying machines and boll weevil "remedies", boll weevil parasites, the Shreveport laboratory, cooperation with the Bureau of Entomology, and experiments with Paris green. Under the last topic is presented the results of several extensive field tests with Paris green against the boll weevil, and a summary of the results of a special tour of investigation made by the Commision through a region where Paris green was extensively used. These experiments showed that no increase in crop resulted from the application of Paris green.

1912 - Hunter, W. D., and W. D. Pierce. The Mexican boll weevil: A summary of the investigations of this insect up to December 31, 1911. Sen. Doc. 305, 188 p.

A rather complete discussion on natural and artificial control.

1915 - Hinds, W. E. Chain drag for boll weevil control. Ala. Agr. Expt. Sta. Press B. 78, 1 fig. June 15. Auburn.

An exceedingly simple and inexpensive mechanical device for weevil control, the value of which has been proven in Texas, is the chain drag, or cultivator. It does not catch the weevils or collect cotton squares, but combines in one process the cultivation of the crop and the collection of the fallen, infested squares to the middle of the rows of the cotton, by drawing over the ground the heavy chains attached to the ends of a beam so that they will assume a semi-circular shape when dragged along. Thus the infested squares are exposed to the heat of the sun and the weevils in various stages are killed.

The device is of special value in hot, dry weather and on soils that are not baked. It is constructed as follows: A spar or log of wood is used, 2 or 3 inches in diameter and fairly heavy, 6 or 8 inches shorter than the distance between the rows of cotton plants. To the ends of this, 2 pieces of chain, one shorter than the other, are attached so as to form 2 loops one inside the other. From 12 to 15 feet will be sufficient for the 2 loops, for a log 3 or 4 feet in length. The best type is a square linked chain, such as is used in logging.

By dragging the log and attached chains for a short distance over a smooth floor, the loops will arrange themselves more or less symetrically. A wire is then attached to the middle link of each chain, and 2 more to the log at about 1/3 of its length from each end; these wires are gathered to and twisted around a piece of wood which will serve as a handle. The wires are of such a length that the man in charge of the drag can conveniently lift the chains over stones or obstacles or use them for guiding the drag. All that is needed further is to attach a draw bar to the log by 2 chains of such a length that the horse, when pulling on it, will not lift the log off the ground.

In dry weather, weevil infested fields should be gone over twice a week with the device. A man and mule can cover 7 to 8 acres a day. When used in dry weather, it will save the extra labor of handpicking infested squares.

1916 - Hinds, W. E. Boll weevil in Alabama. Ala. Agr. Expt. Sta. B. 188, 64 p., 6 pl. Mar. Auburn.

This bulletin deals further with the introduction and spread of the boll weevil in Alabama. Since the infestation must be regarded as permanent, all

possible precautions should be taken in cotton cultivation, such as to reduce the cotton acreage where the necessary labor for cultivation and weevil control is not available, change of crops in a planned rotation, increase of the nitrogen content of the soil by growing leguminous crops, deep preparation of the soil, selection of an early variety of wilt-resistant cotton, and the maintenance of a uniform date for planting.

The weevils themselves may be controlled by many mechanical devices, such as the chain drag or cultivator, handpicking when squaring begins, destroying infested squares, and collecting the insects with a loop and bag apparatus. The cotton should be promptly harvested, and the best seed for weevil resistance should be carefully selected, after which all green cotton should be destroyed as early as possible to deprive the adult insects of their food supply.

To be effective, this stalk destruction should be done a month before the frosts and should be effected by burning and not by the old fashioned grazing method. The stalks may be cut just below the surface of the soil, piled in rows and burned as soon as the leaves are dry enough, the adult weevils and all immature stages being destroyed in this way. Another method of stalk destruction is that of deep ploughing in early autumn, a stalk bender being used to lay the stalks flat upon the ground, so that the following ploughshare completely buries them at the bottom of the furrow.

The principal factors in the natural control of A. grandis are: (1) climatic conditions, especially heat and drought in summer, which caused a mortality of 25%; (2) predaceous insects, primarily fire ants, which destroy 16%; (3) plant proliferation, that is, the rapid growth of new cell tissue after an injury often resulting in the crushing of the newly laid eggs, 12% of these thus being destroyed; (4) parasites, which, however, are not to be depended on, as they destroy only 4%. The help of birds is a welcome, but not a dependable natural factor in boll weevil control.

Two other weevils often mistaken for A. grandis are the cocklebur weevil (Barsi transversa Say), which breeds in cocklebur, and the ragweed weevil in ragweed.

1919 - Pierce, W. D. 1. A program for the eradication of the Mexican cotton boll weevil. 2. The need of immediately eradicating the imported European corn borer and a definite proposal therefor. Gage-Pierce Res. Lab. B. 1:3-14. Dec. Denver.

In view of the extensive annual loss incurred by the ravages of the Mexican cotton boll weevil, a definite working basis is proposed with the Gage-Pierce Research Laboratory as the initial unit for organizing the campaign. The plan suggested involved 10 years' work of preparation for one year of absolute cessation of cotton growing in the Southern States from New Mexico to Virginia.

Funds subscribed for this purpose are to be kept as a trust and used only in connection with activities legitimately lying within the scope of the project.

As soon as the approval of Congress is obtained, the support of organizations of growers, businessmen, and scientific men is to be sought. The officials of the American Assoc. of Economic Entomologists are in sympathy with the movement, and it is hoped that the Association will actively support the project when the plans have been definitely laid before it. Various committees are to be appointed, including those for direction, finance, legislation, demonstration, and inspection; and the first duty of these will be to devise the requisite methods of attack.

A definite plan has been drawn up on which the preliminary committees may build their discussions; this plan is given in detail.

1920 - Conner, A. B. Entomological work. Tex. Agr. Expt. Sta. 33d Ann. Rpt., p. 18-20, 1 fig. Coll. Sta.

A brief account of the measures against various insect pests during 1920. Burning sulphur in the fields at night proved useless in the control of A. grandis.

1920 - Pierce, W. D. A proposition for the reorganization of railroad agricultural work in the interests of efficiency and increased tonnage. Mineral, Metal and By-Products Co., Dept. Biol., Spec. B. 2. Mar. Denver.

In furtherance of his schemes for the eradication of the Mexican cotton boll weevil and other pests the author appeals to the railway companies of the United States to give active support to a service that is designed to report constantly upon insect pest conditions, to enable experts to prepare for probable insect infestations and check them at the start. It is suggested that this should be a joint railroad undertaking, and it is pointed out how greatly the railroads would benefit by the increased tonnage that would result from a decrease in insect depredations.

1923 - Hunter, W. D., and B. R. Coad. The boll weevil problem. U. S. D. A. Farmers' B. 1329, 30 p. June.

Origin, spread, and distribution of the boll weevil. The bulletin includes a description of the weevil and its life history, notes on hibernation, and natural control factors. Effective cultural and chemical control measures are described.

1924 - Harned, R. W., and Others. Biennial report of the State Plant Board of Mississippi for the years 1922 and 1923, 102 p., A. & M Coll.

"The various inspection services are reported on by those in charge of them, in which connection J. E. Lee briefly describes the experiments with the Florida method carried out against the boll weevil . . . with apparently satisfactory results."

1926 - Newell, W., E. F. Grossman, and A. F. Camp. The Mexican cotton boll weevil. Fla. Agr. Expt. Sta. Tech. B. 180. May.

Reviews control measures (natural control, artificial control, dusting, mopping, spraying, and killing of hibernated weevils).

1926 - Walker, H. W., and J. E. Mills. Progress report of work of the Chemical Warfare Service on the boll weevil. J. Econ. Ent. 19(4):600-601. bi-m. 1926.

Preliminary results of a chemical screening program where some 1,000 poisons or poison mixtures were tested. About 50 showed a toxicity equal to or greater than calcium arsenate. Amount of arsenic (soluble As_2O_3) necessary to poison a weevil is estimated at about 0.00015 milligrams. Average weight of a boll weevil is 16 mg.

1927 - Anonymous. Acuerdo sobre la reglamentacion para el combate del "Picudo" del algodon Mexico (Regulations for work against the cotton boll weevil in Mexico). Sec. Agr. of Fomento, Bol. Mens. Defensa Agr. 1(1):14-15, 20-21. Jan.-May. San Jacinto, F.

Regulations, dated April 21, 1927, were issued by the Mexican government for work against the cotton boll weevil, which was becoming a serious pest in the cotton growing districts. Growers were required to report the presence of the weevil, and local authorities to see that measures, including clean cultivation, crop rotation, and dusting with calcium arsenate, were carried out, and that all cotton plants or parts of plants were fumigated or otherwise disinfected before being exported from infested districts.

1936 - Dunnam, E. W. Pilosity of the cotton plant. J. Econ. Ent. 29(6):1085-1087.

Of 2 cotton varieties tested for boll weevil control at Stoneville, Miss., in 1935, the more pilose retained more arsenic pentoxide under all similar test conditions, this character being more important when the plants are dusted dry.

1947 - Gaines, J. C., W. L. Owen, Jr., and Read Wipprecht. Effect of dusting schedules on the yield of cotton. J. Econ. Ent. 40(1):113-115.

Protection of the squares early in the season helped to set the early bolls but failed to produce an increase in the total yield. At College Station in a delayed schedule, picking was about 2 weeks later than in an early dusting schedule. All

cotton was harvested by September 18. Apparently the loss of about 50% of the squares during the first 30-day period of fruiting did not affect the yield at College Station where adequate protection was given the fruit from the ravages of both the weevil and bollworm later in the season. At Terrell, a large percentage of the additional fruit set by protecting the squares from weevils shed, thus reducing the final yields on these plots to a small increase over the check. Apparently the seasonal average loss of about 60% of the squares did not greatly reduce the yield of cotton planted on this soil. Forty percent of uninjured squares produced by the plant were sufficient to yield about all the soil was capable of producing. These results indicate that it may be more profitable to dust cotton during the last 3 weeks of July and August, at which time the weevils and bollworms are most injurious in these areas, than to try to protect the fruit during the entire season.

1957 - Leigh, T. F., and Charles Lincoln. Controlling boll weevils in hill land areas. Ark. Agr. Expt. Sta., Ark. Farm Res., p. 10. Spring.
The benefits of insecticide treatments, early fruiting cotton varieties, and proper date of planting.

1959 - Davich, T. B. New approaches to cotton insects. Farm Chemicals 122: 62, 64, 65. June.
Reviews the use of "new" approaches to boll weevil control: (a) use of systemics, (b) host plant resistance, (c) chemically induced plant resistance, (d) gamma irradiation, (e) hormones and antimetabolites, and utilization of "diapause" phenomenon.

BIOLOGY AND LIFE HISTORY

1895 - Townsend, C. H. T. Report on the Mexican cotton boll weevil in Texas (Anthonomus grandis Boh.). Insect Life 7(4):295-309. Mar.
An important preliminary paper giving valuable data on life history and habits, an account of its spread from Mexico to Texas, and its extent in Texas at that time. In the consideration of remedies are suggested the cutting and burning over of the cotton fields in winter, the abandonment of cotton growing over the region then infested, and the maintenance of a wide zone free from cotton along the lower Rio Grande bordering Mexico, with other suggestions of less practical value.

1898 - Balestrier, L. de. El picudo en 1897. El Progreso de Mexico 5:242-243. Jan. 30.
Brief statement regarding the boll weevil in Tabasco, its parasites, and methods of control. Two machines are briefly discussed.

1901 - Mally, F. W. A preliminary report of the progress of an investigation concerning the life history, habits, injuries, and methods for destroying the Mexican cotton boll weevil (Anthonomus grandis). Authorized by a Special Act of the 26th Legislature of Texas, p. 1-33, Suppl., p. 35-45, State Printer, Austin.
The life history and habits of the weevil are discussed, and insects mistaken for the boll weevil are mentioned.

1901 - Mally, F. W. The Mexican boll weevil. U. S. D. A. Farmers' B. 130, 29 p.
Provides notes on life history and habits of the boll weevil.

1901 - Rangel, A. F. Estudios preliminaries acerca del picudo del algodon (Insanthonomus grandis, I. C. Cu.). Comn. de Parasit. Agr. B. 1(3):93-104. 1901. Mex.
Contains remarks on previous work, importance of the insect, origin and transportation, biology, character of injury, and action of climate on image. Burial of weevils is indicated as futile. Remedies mentioned include: proper soil preparation, destruction of stalks, inundation, selection of seed, destruction of fallen squares, insecticides, and traps.

1901 - Rangel, A. F. Segundo informe acerca del picudo del algodon (Insanthonomus grandis, I. C. Cu.). Comn. Parasit. Agr. B. 1(5):171-176. Nov. Mex.
Remarks on hibernation, migration, and origin of weevils upon sprout cotton and means of destroying them; collection of adults is thought feasible.

1903 - Ballou, H. A. Insects attacking cotton in the West Indies. West Indian B. 4(3):268-286.
Economic and biological notes are presented on the cotton worm, bollworm, Mexican cotton boll weevil, cotton plant louse, scale insects, cutworms, grasshoppers, and species of Phytoptus, and other insects.

1903 - Sanderson, E. D. The Mexican boll weevil. Ent. Dept., Tex. Agr. Expt. Sta. C. 1, Press Notes 5(3):1-5, Feb. 25.
Brief account of the insect, including life history, description, and methods of control.

1903 - Stubbs, W. C., R. E. Boulin, and H. A. Morgan. The Mexican cotton boll weevil. La. Agr. Expt. Sta. C. 1, 10 p., 3 fig., 1 map.
Description of the life history and habits of the boll weevil. Weevils at work in squares can be recognized readily by what is called "flaring," an opening out and spreading down from the bloom of the involucre or shuck, exposing them.

1904 - Morgan, H. A. The Mexican cotton boll weevil. La. State Agr. Soc. Proc. 17th Ann. Sess. and the 6th of the La. Stock Breeders' Assoc., p. 64-71.
General account of the insect, including life history and habits. The necessity for maintenance of quarantines against cottonseed products and other farm products likely to carry boll weevils is emphasized in connection with remaks on the protection of Louisiana from invasion.

1904 - Schwarz, E. A. The cotton boll weevil in Cuba. Ent. Soc. Wash. Proc. 16(1):13-17.
First, it was suspected that this insect might have some native food plants other than cotton. It was impossible, however, to find the weevil upon any plants except cotton. It was feeding upon "loose cotton," and upon "kidney cotton." The weevil is not especially common upon or injurious to either one of these species, but the evidence obtained indicates that the "kidney cotton" is the original food plant of the cotton boll weevil, and the author believes that this insect has no other food plant than species of cotton. No parasites of the cotton boll weevil were found in Cuba.

1904 - Valle, Alfredo del. Enemigos vegetales y animales del algodonero. El Prog. de Mex. ano 11, p. 503-504 and p. 515-516. Aug. 30.
The stages of the weevil are described, life history and habits outlined, and the distribution of the weevil in Mexico is given. Various remedies suggested by investigators are presented.

1904 - Wilcox, E. M. The Mexican cotton boll weevil. Ala. Expt. Sta. B. 129:91-104.
A review of the introduction, history, and present distribution of the cotton boll weevil within the United States. Notes are given on the habits and life history of this pest. While a number of natural enemies have been mentioned as likely to assist in the control of this pest, the author believes that improved methods of cultivation are the only effective means of controlling the boll weevil so as to raise profitable crops.

1905 - Newell, W. The Mexican cotton boll weevil. Ga. State Bd. Ent. B. 12:29, 21 fig.
The cotton boll weevil is described in its various stages, and notes are given on various other phases of the weevil problem, such as the rate of increase and destructiveness of the pest, artificial remedies, the relation of birds to the boll weevil, and insects frequently mistaken for this pest.

1906 - Cook, Mel T. Insectos y enfermedades del algodon. Primer informe anual de la Estacion Central Agronomica de Cuba, p. 178-180.

Probably introduced into Cuba. Brief description and account of life history.

1907 - Newell, W. The boll weevil--Information concerning its life history and habits. Louisiana Crop Pest Comn. C. 9:29.

A summary of the life history and habits of the boll weevil in its different stages, and the means by which it is disseminated, its migration, hibernation, and other matters connected with an understanding of its history.

1911 - Cushman, R. A. Studies in the biology of the boll weevil in the Mississippi Delta Region of Louisiana. J. Econ. Ent. 4(5):432-448.

Oviposition--The female weevil, selecting a suitable place, usually on the surface of the calyx toward the base of the square, begins drilling a hole by pulling off a little flake of the outer epidermis. She thrusts her beak into the tender portion of the square and gnaws out a small cavity. Withdrawing her beak, she places the tip of her abdomen directly over the puncture, into which she thrusts her ovipositor, depositing a single egg in the chamber at the extreme end of the puncture. Then she plugs the puncture with a particle of excrement, pressing it down with the tip of her abdomen. The total time for the whole process varied from 2 min. 45 secs. to 9 mins. 30 secs., with an average of 4 mins. 41 secs. Exclusive of the time lost in hunting for the puncture, one of the weevils accomplished the act in 1 min. 55 secs.

Oviposition of hibernated weevils--The oviposition period lasted from 14 to 53 days, during which time the weevils deposited from 51 to 304 eggs. The average oviposition was 203.33 eggs, and the average period, 34.44 days. The average daily individual oviposition varied from 3.4 to 7.66 eggs, with a total average of 5.9 eggs per day. The maximum number of eggs deposited by any weevil during one day was 20.

Oviposition of latest first generation weevils--Of an original 9 weevils, 4 died without producing any eggs and 1 was lost after 5 days of ovipositing. Of the 4 remaining, ovipositing ranged from 43 to 49 days. During the above period the weevils deposited the following numbers of eggs: 295, 211, 183, and 198. The average total oviposition for the 4 weevils was 221.75 eggs. The average daily oviposition was 4.78 eggs, and the maximum number of eggs deposited by any 1 weevil during 1 day was 12.

The total period from emergence to oviposition varied from 5 to 23 days. The number of eggs produced on the first day of oviposition show remarkable variation--from 1 to 7.

Developmental Period--Incubation period: Data on the incubation period obtained from 6 lots of eggs. Of these, 4 lots deposited June 27 to July 4, showed a period of about 3 days, and 2 lots, deposited July 8-10, gave a period of about 2-1/2 days. The determining factor in the duration of the incubation period was maximum temperatures. The results obtained indicate that the larval period occupies slightly less than half of the total developmental period, and approximately equals the incubation and pupal periods combined. The average developmental period of 92 weevils bred from unopened squares was 13.4 days, 0.4 of a day less than for those in the opened squares. The average mean developmental period as determined above, taken together with the average pre-oviposition period, gives an average total life cycle, exclusive of the oviposition period, of about 20 days. It was noticed that, in general, a relative majority of the earliest weevils reared from the different lots of squares were females and that the percentage of males increased as time passed. Other things being equal, the larger the lot of squares, the better the condition for food, and the shorter the developmental period of the weevils reared.

1911 - Townsend, C. H. T. The cotton square weevil of Peru and its bearing on the boll weevil problem of North America. J. Econ. Ent. 4(2):241-248.

The author's views in regard to the future development of cotton growing in the arid southwest, with special reference to the supposed immunity of this section to the cotton boll weevil.

1912 - Hunter, W. D., and W. D. Pierce. The Mexican boll weevil: A summary of the investigations of this insect up to December 31, 1911. U.S. Sen. Doc. 305, 188 p.
Description of the various stages, a detailed review of its life history, food habits, mating habits, oviposition, and seasonal abundance.

1914 - Worsham, E. L. The Mexican cotton boll weevil. Ga. State Bd. Ent. B. 39, 24 p., 1 fig., 7 pl. Feb.
The weevil is restricted to the cotton plant, and passes the winter in the adult stage, with old cotton stalks, dead leaves, timber, and such affording shelter. A temperature below 12°F. is fatal to hibernating individuals. The date of emergence varies from February to July. The first weevils to emerge feed upon young seedlings, puncturing the stem at or just below the attachment of the cotyledons. One of the first effects of oviposition is the opening of the bracts and the exposure of the bud. The larva hatches in about 4 days and feeds first on the immature pollen in the center of the square, then on the pistil and other tissues of the bud. Many eggs are laid in bolls, and the larvae from these feed on the seeds and occasionally on the immature fibers. During the summer the average length of the larval stage is 8 days. The pupal period varies from 2 to 14 days. Ten generations may occur in one season. Adults of any generation may hibernate on the approach of cold weather.
During spring and summer there is a continual flight of weevils from plant to plant. In autumn, large numbers make flights of considerable length seeking new feeding grounds, the yearly increase in distribution taking place at this time. The weevil may be prematurely carried into uninfested territory in cottonseed products, in wagons, railways, or on clothing.
Numbers of eggs of larvae are killed by the rapid proliferation of the tissues in which the eggs are laid. The only effective methods of control are cultural ones: the destruction of cotton stalks in autumn, clean cultivation, crop rotation, early planting, fertilizing, and working are all important factors. Hand picking of fallen squares proves a satisfactory means of control in some localities; squares should be burned, preferably in wire cages so that parasites may escape. Early varieties of cotton should be selected; those which do not form a top crop late in autumn, which tend to retain infested squares, and which have heavy stems are the best kinds to plant.

1915 - Coad, B. R. Recent studies of the Mexican cotton boll weevil. U. S. D. A. B. 231:1-34.
Includes a report of investigations on the biology of Anthonomus grandis thurberiae at Victoria, Tex., in 1913.

1916 - Coad, B. R. Studies on the biology of the Arizona wild cotton weevil. U. S. D. A. B. 344, 23 p. Jan. 18.
Discusses occurrence, distribution, and biology of Anthonomus grandis thurberiae (Pierce) in wild cotton, and Thurberia thespesioides, in the mountains of southeastern Arizona.

1916 - Howe, R. W. Studies of the Mexican cotton boll weevil in the Mississippi Valley. U. S. D. A. B. 358, 32 p. April 12.
Numerous observations have shown that the complete data secured shortly after 1892 on the biology of A. grandis need revision. Under new climatic and other environmental conditions to which the weevil has been subjected in the course of its spread, changes have been taking place in its life history. A new variety, A. grandis thurberiae Pierce, has also been recorded since that date. Many studies of this pest have, therefore, been repeated under both old and new conditions.
The information given is presented chiefly in a series of 25 tables. In northern Louisiana the average longevity of A. grandis adults on cotton squares was 54.56 days, on bolls 34.41 days, on cotton leaves 8.17, and on okra fruit 5.4. The longevity of the variety thurberiae is greater in every instance, the corresponding figures being 61.4, 48.6, 62.04, and 18.3. In A. grandis the females

exceeded the males on every food except cotton squares, and were also markedly more prolific than those of the variety thurberiae, in which the males were longer lived. The average total developmental period of weevils of both sexes in both squares and bolls was about 14 days. Seven complete generations were developed at Tallulah between the first of June and the first of November, 1914.

1920 - Conradi, A. F. Report of the Entomology Division. S. C. Expt. Sta. 33d Ann. Rpt., p. 41-43. 1919-1920, Dec. Clemson.

The period from oviposition to the emergence of boll weevil adults averages 17-1/2 days. Eggs are laid about 7 days after emergence, giving a complete life cycle of 25 days.

1921 - Smith, G. D. Studies in the biology of the Mexican cotton boll weevil on short-staple upland, long-staple upland, and Sea Island Cottons. U. S. D. A. B. 926, 44 p., 1 pl., 18 fig. Apr. 19.

A study has been made of the biology of A. grandis Boh. occurring east of the Mississippi River, and the results of many tests and observations are given in a series of tables; most of the investigations were made at Madison, Florida. There was practically no difference in the longevity of weevils on sea-island and upland cottons, nor in their developmental period, either in short-staple or long-staple upland, or in sea-island cotton squares. Soil temperatures of 120°F. and higher usually proved fatal to immature weevils under field conditions.

A. grandis in this locality shows a decided tendency to form a new variety. The hibernation of the weevils is incomplete, and the adults are seldom inactive for more than 30 days at a time. Emergence from hibernation is very gradual, the total emergence bearing a direct relation to the total daily rainfall. The total percentage of hibernating weevils that survived the winter of 1918-1919 in Madision, Fla. was 7.54%.

1922 - Sanborn, C. E. Boll Weevil Life History in Connection with Essential Methods of Control. Okla. Agr. Expt. Sta. C. 50, 2 p.

Briefly outlines the life history of the boll weevil and the essential cultural methods for controlling this pest in Oklahoma.

1923 - Hunter, W. D., and B. R. Coad. The boll weevil problem. U. S. D. A. Farmers' B. 1329:30. June.

Origin, spread, and distribution of the boll weevil. The bulletin includes a description of the weevil and its life history, notes on hibernation, and natural control factors. Effective cultural and chemical control measures are described.

1923 - Sanborn, C. E. Suggestions relative to the boll weevil. Okla. Agr. Expt. Sta. C. 53, 12 p., 11 fig. Stillwater.

This paper, in part, is identical with C. 50 (1922) but gives additional information concerning the weather conditions favorable and unfavorable for the weevil, as well as a comparison between it and other weevils with which it may be confused.

The application of poison as advocated by the U. S. Bureau of Entomology was not recommended in Oklahoma until further experiments proved this method to be satisfactory under existing conditions.

1925 - Morrill, A. W. Commercial entomology on the west coast of Mexico. J. Econ. Ent. 18(5):707-716.

The West Coast weevils appear from physical characteristics to be a mixture of the typical Anthonomus grandis and the variety thurberiae. Ten specimens collected in the Yaqui Valley in 1924 were considered to be quite typical of grandis. From investigations so far made, the writer has proved the Yaqui Valley weevils well adapted to extremely high temperatures and moderately low humidity, conditions which would in all probability exterminate the typical grandis if these conditions would be duplicated in our Southeastern States where the grandis form exists.

1926 - Dunnam, E. W. Cotton boll growth in relation to boll weevil injury. J. Econ. Ent. 19(4):589-593.

Evidence that as the cotton bolls grow older they are less susceptible to injury by A. grandis, and the immunity at given ages varies with the variety. There is no correlation between the number of feeding punctures or the number of egg punctures and the percentage of cotton loss. Neither is there any relation between the thickness of the boll and susceptibility to weevil damage, in spite of the fact that the weevils lay fewer eggs in the thick-bolled varieties. The determining factor is the hardness of bolls, because varieties with the hardest bolls, as determined by the number of grams pressure required to puncture them, show also the lowest percentage of cotton loss.

1926 - Gray, D. T. Report on entomological work, 1925-26. Ark. Agr. Expt. Sta. B. 215:29-31. Nov. Fayetteville.

Tests were made to determine the usefulness of tracing the spread of infestations of the cotton boll weevil from areas infested by hibernating weevils, the value of following the development of broods as an aid to timing dust applications, the effectiveness of dust as a barrier to migrating weevils, and the value of repressing scattered infestations in the field and delaying the dusting over the whole field until a serious threat of injury was first noticed. The tests were made on two plantations that had previously been heavily infested. Practically all the midseason infestation could be traced to areas infested by hibernating weevils. No complete break was observed between the period of infestation by the hibernating and first generations. Dusts applied on and around areas infested by these weevils prevented the migration of the weevils and suppressed the infestation to such an extent that the cotton continued to fruit until about August 12, when the general migration of the weevils began.

1926 - Isely, Dwight. Early summer dispersion of the boll weevil. J. Econ. Ent. 19(1):108-112.

The dispersion of the cotton boll weevil in a field, after the hibernating weevils have become established, is periodic. Each period of dispersion coincides with the emergence of a new brood of weevils. The spread of weevils across a field is usually direct from plant to plant or row to row, and is not the result of long flights. Newly emerged weevils do not usually migrate until sexual maturity is attained. This information was used in locating infestations at the beginning of the 2d and 3d periods of dispersion and in timing dust applications. Small infested areas dusted before weevils reached sexual maturity resulted in apparent extermination of infestation.

1926 - Isely, Dwight. Early summer dispersion of boll weevil with special reference to dusting. Ark. Agr. Expt. Sta. B. 204, 17 p. Feb. Fayetteville.

Small areas in cotton fields infested by overwintering weevils are usually difficult to locate until squares begin to flare and fall, or until the greatest activity of this brood of weevils is past. It was found that these infested spots are the centers of spread, and if they are marked, later infestations can be easily traced to them. When the infested areas are marked and kept under observation, it is easy to note the earliest activity of the weevils to develop in the field. The relatively long nonmigratory feeding period of approximately a week gives ample time for making dust applications, not only before weevils have spread but before they have begun reproducing. Small infestations, both at Marianna and Varner, dusted at this time, were apparently exterminated.

1926 - Isely, Dwight. Insect pests in Arkansas, 1924-25. Ark. Agr. Expt. Sta. B. 203:32-40, 3 fig. Fayetteville.

"A short account is given of the dispersion and seasonal habits of the boll weevil (A. grandis) in cotton fields."

1926 - Newell, W., E. F. Grossman, and A. F. Camp. The Mexican cotton boll weevil. Fla. Agr. Expt. Sta. Tech. B. 180. May.

Reviews history of boll weevil. Discusses biology of boll weevil in Florida. Describes emergence from hibernation and migration.

1927 - Hinds, W. E. Notes on the biology and habits of the Peruvian cotton square weevil. Ent. Soc. Amer. Ann. Rpt. 20(2):251-254.

Anthonomus vestitus has a much lower reproductive capacity than A. grandis Boh., with which its habits are compared, and it is believed to be a much less serious pest than the latter.

1928 - Anonymous. Instrucciones para combatir el picudo del algodon, Anthonomus grandis, el picudo de la para, Epecaerus cognatur, la hormiga arriera, Atta ferveus. (Instructions for combating the cotton boll weevil, the potato weevil and the leaf-cutting ant).
Bol. Divulg. Oficina Defensa Agric. Sec. Agric. Fom. Nos. 5-7: 6 p., 3 fig; 6 p., 5 fig; 15 p., 10 fig., San Jacinato, D. F., Mex.

These are popular pamphlets on the bionomics and control of the insects mentioned in the title, all of which are serious pests in Mexico.

1928 - Fenton, F. A., and E. W. Dunnam. Dispersal of the cotton boll weevil (A. grandis, Boh.). Agr. Res. J. 36(2):135-149.

The behavior of A. grandis Boh. differs considerably during the summer flight period, compared with earlier in the year. This phase of bionomics of the weevil was studied during 1924 and 1925. The beginning of the flight period was about 5 weeks earlier in 1925 than in the previous year. Flight is earlier in the more heavily infested fields, the tendency being to leave these for those that are less heavily infested. The weevils become restless and take wing when the percentage of infestation reaches a certain point (not yet determined). More males were caught on the screens than females. Though the weevils may fly when the maximum temperature is between 60° and 80°F., the most favorable conditions are between 80° and 100°F. The temperature, however, is of secondary importance and acts only after the stimulus to flight has been aroused.

1928 - Grossman, E. F. Florida longevity records of the cotton boll weevil. Fla. Ent. 12(4):57-59, 2 ref. Dec. Gainesville.

Of 4,000 adults of Anthonomus grandis placed without food in a hibernation cage in November 1927, the emergence of which was observed from March 1 until August 8, 1928, 11.24%, or 562 weevils, emerged--the last on July 16, after having spent 275 days without food in the hibernation cage. In order to determine the number of days that weevils could live after hibernating, all those emerging after June 14 were provided with fresh cotton squares and placed individually in lantern globes kept in an insectary under approximately normal conditions. Longevity records show that one of these weevils lived 143 days after emergence from hibernation and another lived a total of 372 days (238 in hibernation and 134 afterwards.)

1928 - Grossman, E. F. Resumption of egg-laying by hibernated cotton boll weevils (Anthonomus grandis Boh.). Fla. Ent. 12(3):33-38, 3 ref. Sept. Gainesville.

In order to be sure that the weevils used had not previously fed on squares, individuals emerging from hibernation were chosen. There was a marked difference in the egg-laying activities of females fed on lower (fully developed) and terminal (growing) leaves and comparatively little difference in the activities of those fed on terminal leaves or squares.

The terminal leaves and squares were analyzed for a comparison of ether extracts, total nitrogen, and carbohydrate content, and the results indicate that no great significance can be attached to the chemical difference with regard to egg-laying. Weevils fed on the lower leaves and then on squares deposited their first egg 4 days after feeding on the latter. This was also the time required by weevils feeding on squares without a previous diet of leaves. Weevils first fed on terminal leaves deposited their first eggs within 24 hours after feeding on squares, so that it may be assumed that if any vitamin is in question, it occurs both in the terminal leaves and the squares.

It is suggested that egg-laying depends chiefly on concentrations of diet. Fully grown leaves apparently meet the requirements for life but not for

oviposition, while growing leaves appear not only to sustain life, but also to stimulate egg-laying by supplying the necessary food concentration. The question of oviposition is important from the point of view of poisoning the weevils when they emerge from hibernation. If it is realized that the weevils feeding on the cotton buds prior to the appearance of squares will lay their eggs on the latter as soon as they appear, early poisoning should be rigorously followed; but if it is believed that they must first feed on squares, poisoning may be delayed long enough for the hibernated weevils to establish the next generation.

1928 - Isely, Dwight. Ark. Agr. Expt. Sta. 40th Ann. Rpt.--B. 231:48. Dec.

Larvae of boll weevil feed and develop either in squares or in bolls. They prefer squares as food. While they deposit eggs in bolls, they must have squares or very young bolls as food if reproduction is to continue. Weevils feeding on large bolls exclusively would not produce eggs. Those feeding on small bolls reproduced at a lower rate than those fed on squares. There was a definite relationship between abundance of squares in fields late in season and the presence of overwintered weevils in the field the following spring.

1928 - Isely, Dwight. Oviposition of the boll weevil in relation to food. J. Econ. Ent. 21(1):152-155.

Studies carried out in 1926 and 1927 showed that while larvae of A. grandis feed and develop either in squares or bolls of cotton, adult weevils show a preference for squares. Experiments based upon daily oviposition records of 110 mated pairs, the food of which was controlled from the date of emergence until death, indicated that not only are the longevity and period of oviposition of weevils fed upon squares greater than that of those fed exclusively on bolls, but squares and small bolls are essential for reproduction. Weevils fed exclusively on squares deposited an average of 110 eggs, the average oviposition period being 21.18 days and the average longevity 26.27. The figures for females fed solely on small bolls were 17.7, 13.8, and 25.5. Most of the weevils fed exclusively on large bolls deposited no eggs, while the longevity period was 23.17 days. None of the weevils that were fed upon large bolls for the first 10 days after emergence and then changed to squares began oviposition until after the change was made. Eighty percent began depositing eggs after an average interval of 3.72 days from the change of food, the number of eggs deposited being 34.9, and the oviposition period 10.3 days. Weevils which fed on squares for 10 days and then changed to large bolls stopped oviposition on an average of 3 days after the change of food.

In the latter part of the season if the formation of squares stops, oviposition soon ceases. The requirement of squares for reproduction limits the number of weevils that go into hibernation. This was also a factor in the local distribution of overwintering weevils, as field observations indicated a tendency for them to migrate to fields where squares were most abundant at the end of the season.

(In a discussion that followed the presentation of this paper, the author stated that as the weevil is largely a feeder on pollen in the squares, nitrogen content is probably the factor controlling oviposition and longevity.)

1929 - Dunnam, E. W. Experiments on the relation between the location of cotton fields and the intensity of boll weevil infestation the succeeding season. J. Econ. Ent. 22(5):750-756.

Experiments on the migratory habits of the cotton boll weevil were carried out in Louisiana in 1928 by means of screen traps under conditions that were peculiarly favorable, as floods in 1927 had destroyed large areas of cotton. Observations were carried out both in fields where cotton had been grown in 1927 and also in cotton situated at varying distances up to 3 miles from the site of an isolated extensive cotton planting of that year. Additional tests were made in woods and in an unplanted field a mile away from the site of this planting.

Screens treated with adhesive were set up between May 28th and June 2d, and observed daily. Records were kept to determine the effect on dispersal of relative abundance of weevils, supply of food, and distance from breeding-places, and height of the cotton plants.

The results secured, though not conclusive, indicate that there was no relation between the spring infestation in 1928 and the situation of scattered cotton plantings in 1927, though distance from a supplementary source of weevils may be an important factor in early spring infestations.

1929 - Fenton, F. A., and E. W. Dunnam. Biology of the cotton boll weevil at Florence, S. C. U. S. D. A. Tech. B. 112, 75 p.

Climate exerts an important influence on the seasonal cycle. Temperatures of 11°F. or lower are unfavorable to overwintering weevils; hot, dry summers are also unfavorable. Squares punctured once remained on the plant for an average of about a week. Those more than 6 days old were always preferred for oviposition. For feeding, the younger the boll, the more frequently it was punctured. Four generations occurred in a season, the first and second being large, and the third and fourth incomplete. The maximum emergence and oviposition of the different generations took place before the middle of August. Development of the weevil was most rapid during the period of maximum production of squares and was less after the plants had shed most of the squares and young bolls. The longevity and pre-oviposition periods of weevils in cages under varying conditions is discussed. Trap-crop records indicate that flight dispersal began about mid-July in 1925 and 1926. Temperature influenced flight to some extent, even after it was initiated, more weevils flying at high temperatures. Dispersal was also correlated with the percentage of infestation.

1929 - Grossman, E. F. Biology of the Mexican cotton boll weevil. III. The mechanism of grub feeding. Fla. Ent. 13(2):32-33.

It is suggested that the larva of Anthonomus grandis does not eat its way out of the cotton boll because it prefers the soft interior to the hard shell and, therefore, mechanically avoids the numerous dangers to which it would be exposed on the exterior of the boll. In experiment with infested bolls in which the outer shells had been made as soft as the contents, or the latter dried as hard as the shells, the grubs in both cases began to bore through the walls.

1929 - Grossman, E. F. Biology of the Mexican cotton boll weevil. IV. Duration of fertility after copulation. Fla. Ent. 13(3):41-43.

Females of Anthonomus grandis Boh. were isolated after mating, and kept for various periods in artificial hibernating quarters at a temperature of 55°F. They were then placed on fresh cotton squares in an incubator at 80°F. Fertile eggs were laid for periods up to almost 7 months after mating had occurred.

1930 - Calhoun, P. W. Time of hatching first generation boll weevils relative to appearance of blossoms. Fla. Ent. 14(4):72-75.

In order to be able to predict when first generation weevils might be expected to emerge, squares of an upland and a sea-island variety of cotton were measured between May 29th and June 6th. The time between the date of measuring and the date of blossoming was recorded and correlated with the period required for a weevil to develop from the egg in the field in Florida; that is, 21-22 days. It was found that for a weevil to emerge from the upland cotton before blossoming time, it would have to develop from rather small squares of about 4.5 mm. in diameter at the time of oviposition. Weevils do not ordinarily develop in squares smaller than this. Very small squares dry so readily after they fall from the plants that the larvae they contain die. On the other hand, weevils of the first generation may easily emerge within 3 or 4 days after the first blossoms appear, as squares of 5.5 to 6.0 mm. can easily produce weevils in that time, except under unfavorable weather conditions. Although only one variety of upland cotton was tried, it was thought that other standard varieties would not show sufficient differences to be of importance. Some of

the sea-island varieties, however, might possibly have a pre-bloom period sufficiently long to permit first generation weevils to begin emerging several days before the first blossoms appear. Ordinarily they do not emerge so early in sufficient numbers to cause damage, as a large percentage of the eggs first laid are killed by the hot sun before the cotton plant is large enough to furnish sufficient shade.

If rainy weather prevails from the time the infested squares begin to fall, and no hot sunny weather occurs, first generation weevils begin to emerge by the time the blossoms appear or shortly afterwards, and may easily become sufficiently numerous within 3 weeks to puncture many of the bolls.

1930 - Grossman, E. F. Biology of the Mexican cotton boll weevil. V. Diurnal observations of the emergence of boll weevils from their hibernation quarters. Fla. Ent. 14(3):45-52.

Experiments in Florida showed that A. grandis Boh. usually leaves its hibernating quarters during the daytime, though emergence at night was also observed. Owing to the fact that in every year individuals emerge daily from March 1 to mid-July, regardless of climatic conditions, it appears that the weevils appear when they are physiologically ready to do so, and that daylight, rainfall, and rises of temperature have little effect in accelerating the process.

1930 - Grossman, E. F. Biology of the Mexican cotton boll weevil. VI. Some humidity and temperature effects on development and longevity. Fla. Ent. 14(4):66-71.

Owing to the difficulty encountered in keeping adults of A. grandis Boh. alive in low temperature incubators equipped with brine coils, experiments were undertaken to determine the optimum range of relative humidity necessary for successful hibernation in artificially cooled environments. Relative humidities ranging from 1% to 100% were obtained by means of sulphuric acid solutions. The length of life of adult weevils was determined at various temperatures from 2°C. to 27°C. (35.6° to 80.6°F.), and data on hatching and development of 21° to 27°C. (69.8° to 80.6°F.), with 16 to 19 different humidities. The results are shown in detail in tables. For a period of several days the adults can withstand any percentage of humidity, though a range between 61 and 98 was necessary for continued activity.

1930 - Webb, J. L., and F. A. Merrill. Cotton or weevils. U. S. D. A. Misc. Pub. 35 (revised), 16 p.

A popular account of the bionomics and control of the cotton boll weevil in the United States.

1931 - Grossman, E. F. Biology of the Mexican cotton boll weevil. VII. The boll weevil in artificial hibernation quarters. Fla. Ent. 15(2):21-27.

A new type of cage is described in which various factors influencing hibernation of Anthonomus grandis Boh. could be observed. The weevils were negatively geotropic when seeking hibernation quarters, and it was probably this influence that caused the majority to choose the uppermost of a series of horizontal tubes containing Spanish moss. Moisture also seems to attract the weevils, so much so that in Florida it has been necessary to move cotton plantings away from areas near ponds and containing trees bearing Spanish moss. The weevils hibernated there very successfully and reappeared in such numbers that cotton could not be produced economically. Hibernation of the weevils in cages exposed to varying temperature and relative humidity appears to be as successful as in cages kept at constant optimum temperature and relative humidity.

1932 - Gaines, J. C. Studies on the progress of boll weevil infestation at various distances from hibernation quarters. J. Econ. Ent. 25(6):1181-1187.

The relation between the progress of infestation by Anthonomus grandis Boh. in cotton at various distances away from the hibernation quarters and the flight of the weevils was determined by a study carried out in Texas in 1930 and 1931. The degree of movement from field to field was indicated by traps situated in and between cotton fields. Extensive migration began about September 15th, or just after the maximum number of weevils was caught in heavily infested fields, and when 75% of the squares were punctured.

In 1931, in order to determine the time taken by weevils to spread various distances from hibernation quarters, traps were placed at intervals varying from 1/8 to 1-1/4 miles from woodland bordering a strip of level land mainly planted to cotton. In both seasons as infestation increased, the accumulative catch on the traps did so, also, to approximately the same degree.

In 1931, no weevils were caught in the traps set up in March until July 23d. The first infestation was recorded on June 18th in cotton nearest to favorable hibernation quarters, when 3% of the squares were punctured. In 9 weeks the percentage had doubled and the weevils had spread 3/4 mile. About 3 weeks later they had again spread approximately as far again. Weevils were first taken on the traps at 3/4, 1, and 1-1/4 miles on September 4th, 7th, and 11th, respectively. They thus appear to spread in cotton slowly for the first part of the season up to a point when they begin to migrate more rapidly and cover a larger territory.

The maximum number of weevils was caught on a trap situated on a clear section between hibernation quarters and cotton during the first week in September, when movement in large numbers was taking place from field to field and distribution had become general. At this time weevils were caught at the greatest distances from hibernation quarters. This general migration occurred during a dry season, and may occur earlier in some years than in others.

The maximum fruiting date in the later planted cotton around the trap situated at the farthest point from hibernation quarters did not occur until the end of August. The abundance of fruit on this cotton was attractive to the weevils after the general migration period had begun, and the numbers caught there after September 11th were greater than on traps nearer the hibernation quarters.

1933 - Calhoun, P. W. Irregularity among cotton plants in time of fruiting as a factor affecting susceptibility to damage by the cotton weevil. J. Econ. Ent. 26(6):1125-1128.

A considerable variation in the date of fruiting of different cotton plants growing together, whether due to environmental or to varietal differences, would obviously lead to greater damage by Anthonomus grandis Boh. The few early plants would serve as breeding places for weevils that would migrate to the later plants before the bolls on the latter had matured. Of 600 plants observed in a field in Florida, the very earliest blossomed 12 days earlier than the last half. Maximum frequency of blossoming occurred on the 11th day. In an entirely uninfested field, the half of plants that blossomed earlier might be expected to produce more cotton than the last half. However, a large proportion of the plants that actually produce an average number of bolls began to fruit 9 to 10 days later than the earliest 10%. The presence of the very early plants in a heavily infested field would have reduced the crop, rather than increased it.

1936 - Smith, G. L. Percentage and causes of mortality of boll weevil stages within the squares. J. Econ. Ent. 29(1):99-105.

The chief factors effecting boll weevil mortality in the immature stages are climate, predators, parasites, and proliferation. Of these, climate is ordinarily the most important in the case of fallen squares, although of relatively small

importance in hanging squares. In both cases, the order of efficiency of the other factors seems to be parasites, predators, and proliferation. Temperature is the most important element in the climatic factor, and this has its greatest effect on squares lying on the ground, exposed to the sun. The effective fatal maximum temperature is around 93°F. upward, varying in efficiency almost directly with increase above that figure.

1936 - Watts, J. G. Entomology and Zoology. S. C. Expt. Sta. 1935-36 Rpt.49:39-50. Clemson.

Sericothrips variabilis Beach constituted about 75% of all thrips on young cotton and was more abundant than usual on other plants. By means of marking experiments, it was shown that stalks severely injured by thrips produced fewer blooms and bolls than uninjured stalks. Also, they were 10 days later in starting to bloom, so that more of the crop was heavily attacked by the boll weevil.

1937 - Dunnam, E. W., and J. C. Clark. Thrips damage to cotton. J. Econ. Ent. 30(6):855-857.

It is probable that under field conditions the loss resulting from infestation by thrips would be greater, as the retarded production of bolls would increase infestation by the boll weevil.

1941 - Stuckey, H. P. Ga. Agr. Expt. Sta. 1940-41 Ann. Rpt. 53:118.

A somewhat overlooked habit of the boll weevil was noted during the winter. A number of seed containing live boll weevils were found in December and January. The weevils had fed in the seed as larvae, had left their skins there, and had transformed to adults in the seed. In one seed the larva had been killed by a common parasite Microbracon mellitor (Say).

1942 - Fenton, F. A., and K. S. Chester. Protecting cotton from insects and plant diseases. Okla. Agri. Expt. Sta. C. 96, 32p., 13 fig., 1 ref. 1942. Stillwater.

Anthonomus grandis Boh. is most injurious in the southeastern counties, where the winters are mild, abundant woodland provides protection during winter, and rain is usually frequent during the growing season; but it occasionally causes severe losses over a considerable part of the cotton area when climatic conditions become favorable. There are 2 complete generations and a partial third and fourth during the year.

1942 - Little, V. A., and D. F. Martin. Cotton insects of the United States. ii - 130 p., multigraph, 12 fig., many ref., Minn. Burgess Pub. Co., Minneapolis.

A summary of the results of the large amount of work by entomologists on the insects that attack cotton in the United States. Mainly their bionomics and control, but information is included on distribution, alternate food plants, and the morphology of the various stages. There are two sections: The first (p. 1-79) deals with insects that feed on the squares, flowers, and bolls; the second (p. 81-127), with those that attack the leaves, stems, and roots. About half of the first section is devoted to Platydra (Pectinophora) gossypiella Saund., Heliothis armigera Hb., and Anthonomus grandis Boh.

1950 - Isely, Dwight. Control of the boll weevil and the cotton aphid in Arkansas. Ark. Agr. Expt. Sta. B. 496. June Fayetteville.

Life history and seasonal history, insecticide timing, coverage, methods of effectiveness, and boll weevil in winter.

Persistence of infestation through the season is favored by rank cotton and indirectly by fertility and high water-holding capacity of the soil.

1959 - Fye, R. E., W. W. McMillian, and A. R. Hopkins. Time between puncture by the boll weevil and fall of the punctured cotton square. J. Econ. Ent. 52(1):134-136.

Study of the time a cotton square remains on a plant after it has been punctured by a boll weevil showed no difference in this respect between Empire WR, Dixie King, and Coker 100 W varieites. The number of punctures and the type of puncture, whether feeding or oviposition, had little or no effect. Squares were retained an average of 11 to 13 days. Twenty percent of the squares remained on the plant and produced usable lint. Plants treated with gibberellic acid retained more punctured squares than untreated plants.

1959 - Fye, R. E., W. W. McMillian, A. R. Hopkins, and R. L. Walker. Longevity of overwintered and first generation boll weevils at Florence, S. C. J. Econ. Ent. 52(3):453-454.

The average life of overwintered boll weevils after emergence from hibernation was 20 to 22 days, and ranged from 1 to 141 days. Fat analyses showed that weevils containing most crude lipids lived the longest. First-generation weevils lived 9 to 115 days, with an average of 41.5 days. There was no correlation of total crude lipids with longevity in the first generation.

1960 - Beckham, C. M., and L. W. Morgan. On the flight distance of the boll weevil. J. Econ. Ent. 53(4):681-682.

For a planting of cotton to be isolated from the boll weevil, it must be removed from other cotton by a distance greater than 25.5 miles. Under similar conditions in this area of Georgia, population studies on the boll weevil may be conducted until about August 15 without contamination by migratory weevils.

1960 - Miner, Floyd D. Cotton insects in Nicaragua. J. Econ. Ent. 53(2):291-296.

The cotton-insect problem in Nicaragua is in many respects similar to that in the United States. The most serious pests are the boll weevil and Sacadodes pyralis Dyar, a Phalaenid which bores into bolls. The boll weevil passes the dry season between crops in old cotton fields. Reproduction apparently ceases during this time. Early infestations in young cotton were heaviest in fields planted before the usual date. Peak infestations occurred when the crop was approaching maturity. The life cycle is similar to that in the United States. Sacadodes also was generally a late season pest, and was particularly serious in late planted fields. Infestations of both insects were reduced by means of insecticides, but increases in yield were small.

ECOLOGICAL STUDIES

1902 - Hudson, E. H. The Mexican boll weevil (Anthonomus grandis). Tex. Farm & Ranch 21:13. Feb. 1.

An account of some experiments regarding the effect of freezing and the heat of the sun on the boll weevil.

1912 - Hunter, W. D., and W. D. Pierce. The Mexican cotton boll weevil. U. S. D. A. Bur. Ent. B. 114:23-29.

Contains references to the relation of arid and semi-arid conditions on Anthonomus grandis.

1914 - Hunter, W. D. Ent. Soc. Wash. Proc. 16(1):27-28.
Remarks by the author on cotton growing in semi-arid and arid sections with reference to A. grandis and A. grandis thurberiae.

1928 - Isely, Dwight. The relation of leaf color and leaf size to boll weevil infestations. J. Econ. Ent. 21(4):553-559.
Field experiments in 1925 and 1926 indicate that the boll weevil has marked preference for cotton plants with green foliage to those of red foliage. It apparently has little preference for small, as compared to large, leafed varieties, providing the size and vigor of the plants are about the same.

1935 - Fenton, F. A., and E. Hixson. Effect of the 1934 drought upon the boll weevil in Oklahoma. J. Econ. Ent. 28(5):760-765.
In 1934 a severe drought so effectively checked an early boll weevil infestation that practically no damage was done to cotton by this pest. Due to extremely high temperatures the weevil was almost exterminated in fallen squares. It was able to survive, however, in fairly large numbers in cotton bolls which were not affected by the heat. The broods of weevils emerging from bolls late in the summer produced a large supplementary fall generation in late squares which were developed in unusually large numbers by the plants due to heavy rains in September and November. Because of late frost this large supplementary brood went into hibernation in good condition.

1937 - Hixson, E., and C. A. Scooter. Temperatures at which boll weevils freeze. J. Econ. Ent. 30(6):833-836.
The boll weevil was much more resistant to cold than was formerly supposed. The undercooling temperatures of 991 boll weevils show a range from 26.6° to 9.4°F. Those undercooled in November and February were the most resistant, while those undercooled in December and March were the least resistant. Winters having low minimum temperatures were followed by small field populations of hibernating weevils, whether the population the previous fall was large or small.

1939 - Hixson, E. Okla. Sta. (Bien.) Rpt. 1937-38.
A brief report on resistance studies of boll weevils to relatively low temperatures.

1942 - Gaines, J. C. Several important insect pests of cotton - 1. Relation of production to migration. 2. Insecticidal studies for their control. Iowa State Col. J. Sci. 17(1):63-65.
Work conducted over a period of years in the Brazos River bottoms near College Station, Tex. with the boll weevil, cotton fleahopper, bollworm, and flower thrips.

1943 - Hamner, A. L. The effect of boll weevil infestation. Miss. Farm Res. 6(6):4-5, 4 illus.
Cotton plants react to the loss of squares punctured by the boll weevil by setting a higher percentage of the younger bolls and by producing heavier bolls.

1943 - Hamner, A. L. The effect of boll weevil infestation at different levels on cotton yield. Miss. Agr. Expt. Sta. B. 389, 10 p.
The cotton plant reacts to the loss of squares of the size punctured by the boll weevil by setting a higher percentage of the young buds and by producing heavier bolls.
The percentage of young bolls that matured was higher on plants that had as few as 10% of the squares removed throughout the season than on untreated checks. This percentage increased from week to week as the percentages of

squares removed were increased. Fewer bolls were required to make a pound of seed cotton on the treated plots than on the check. When the bolls were protected from weevil damage, the decrease was 9 or more bolls per pound on those plots that had all of the squares removed after the 7th week of square production.

The highest average yield the first year was made by plots that had 10% of the squares removed the first week of square production, increased by 10% each week through the 5th week to 50%, and held at that level for the remainder of the season. The greatest loss from this treatment in August of 1 of 3 years was 5.5%. Plots that had the percentage of squares removed increased to 40 the 4th week and held at that level for the remainder of the season, exceeded the yield of the check 2 years, and yielded within 1 percent of it the 3d year.

The average percentage of locks lost on bolls was 1.05% in 1939 and 1.1% in 1942 for each percentage of weevil infestation on the day the bolls were marked as blooms. A very high weevil infestation that developed within a short time, late in the season of 1940, caused severe damage to bolls set on cotton that had been delayed in fruiting by a flood.

Exclusive of a few bolls set very early and late in the season, 4 varieties of cotton set approximately 80% of the crop during the 1st 5 weeks of fruiting and over 70% during the 2d, 3d, 4th, and 5th weeks.

1959 - Gaines, R. C. Ecological investigations of the boll weevil, Tallulah, La., 1915-1958. U. S. D. A. Tech. B. 1208, ARS, 20 p. Sept.

Ecological and attractancy studies on the boll weevil were conducted at Tallulah, La., during the period 1915-1958. Records on winter survival in Spanish moss were made from 1916 to 1940 and in ground trash from 1937 to 1958.

Temperatures below 20°F. were fatal to most of the weevils hibernating in Spanish moss. Survival from ground trash was more closely related to the number of weevils in the field during May and June. Hibernation cages did not provide a reliable estimate of winter survival. High correlations were found between winter temperatures, weevil survival, summer rainfall, and cotton yields. The insect was more tolerant to calcium arsenate late in the season than earlier.

Longevity records of 690 overwintered weevils during the period 1934-58 showed that some live longer than 383 days. Flight screen studies showed that 8-mesh hardware cloth, coated with a mixture of tanglefoot plus $37\frac{1}{2}$% of castor oil on a stationary wooden frame, the bottom of which was 3 feet from the ground, provided a satisfactory method for collecting the boll weevil and other insects in flight. Screen direction had little effect on the total number of insects caught. Studies with revolving screens, which at all times faced the wind, showed that more boll weevils were taken on the leeward side. A greater number of insects were taken on screens 3 feet above the ground than at higher altitudes. Boll weevils became active during the hibernation period and took to flight when the temperature reached or exceeded 62°F. Chemotropic studies of trimethylamine and ammonium hydroxide on flight screens indicated that these chemicals had some attraction for the boll weevil in the absence of cotton.

EFFECT OF WEATHER

1908 - Sanderson, E. D. The influence of minimum temperatures in limiting the northern distribution of insects. J. Econ. Ent. 1:261.

The apparent killing out of the weevil in certain sections by low winter temperatures.

1909 - Hunter, W. D. Boll weevil situation in Oklahoma. Okla. State Bd. Agr. Mo. Press B. 7, p. 2-3. Sept. 1.

A statement regarding the scarcity of boll weevils in Oklahoma due to the heat and drought. The early fall destruction of stalks is urged so as to take advantage of the natural setback the weevil has received.

1916 - Pierce, W. D. A new interpretation of the relationships of temperature and humidity to insect development. Agr. Res. J. 5(25):1183-1191.

The effect of temperature on insect development has often been inadequately recorded, especially the higher limits, largely owing to the fact that most work on the subject has been done in the North Temperate Zone where temperatures sufficiently high to affect development do not occur. It is only quite recently that attempts have been made to correlate the humidity factor. The author used as material the records of thousands of individual boll weevils, A. grandis and A. grandis thurberiae, obtained in Texas, Louisiana, and Arizona between 1902 and 1915.

It is generally held that the activities of a species reach a maximum of efficiency at a certain definite temperature, but the author suggests a zone of humidities and temperatures of more or less restricted areas as more probable, and, in the case of the boll weevil, this lies near 83°F. and 65% relative humidity. The relation of the stages of hibernation, activity, and estivation to temperature, and the upper and lower fatal temperatures, have been constantly recorded without reference to the humidity factor.

A diagram is given showing a combination of the temperature and humidity records, which result in a series of concentric eliptical areas, each of which represents a stage in the progress from maximum efficiency to dormancy and death. Details are given as to methods of calculations used. One of the results of this method will be the necessity for discarding the conception of separate zones of estivation and hibernation. The author has repeatedly noticed the impossibility of differentiating between a boll weevil larva killed by heat and one killed by cold.

1925 - Yothers, W. W. Report of the frost damage. J. Econ. Ent. 18(2):425.

"Contrary to the report that the cotton boll weevil (A. grandis) had been exterminated by the cold, an apparently healthy adult weevil was found, shortly after frost, hibernating in an orange grove."

1932 - Isely, Dwight. Abundance of the boll weevil in relation to summer weather and to food. Ark. Agr. Expt. Sta. B. 271, 34 p.

Favorable climatic conditions shorten the life cycle to an extent that accounts for the suddenness of outbreaks of the weevil; nevertheless, unfavorable weather in June and July may reduce the numbers so that potential outbreaks fail to materialize. An increase in temperature from 69.8° to 87.8°F. shortens the cycle from egg to adult by one-half, and an increase from 78.8° to 87.8°F. shortens it by about 20%. The mean temperatures in Arkansas during the critical months of June, July, and August are usually within the optimum range for development (77° to 86°F.).

Sometimes favorable temperatures are delayed until late in June, in which case the fruiting of cotton is delayed correspondingly. After cotton begins fruiting, variations in temperature may accelerate or retard the life cycle but are never sufficient to change the number of generations occurring during the critical period of cotton production, though they do affect the time of maturity of the first 2 generations. Boll weevils can survive in large numbers only between 73.4° and 82.2°F., the optimum apparently being 75.2° to 77°F. A rise in temperature from 77° to 84.2°F. results in an increase in the number of eggs deposited of about 70%, whereas a drop from 77° to 71.6°F. may result in a reduction of about 50%.

An increase in relative humidity from 50% to 90% consistently hastens development. In the field, the relation of humidity to the rate of development is so over-shadowed by the effect of temperature that its importance is not readily recognized. Relative humidity during the summer is the most important factor affecting the survival of immature weevils. The survival of immature stages in squares appeared to be negligible at a relative humidity of 50%, and near optimum at one of 90%. In the field, relative humidity is probably never unfavorably high but is often low enough to be distinctly unfavorable. A summer drought therefore often causes potential outbreaks to fail to materialize.

The weevil develops more rapidly in squares than in bolls and more rapidly in small bolls than in large ones. Squares are the only food available in the early part of the reproduction season, and they are far more abundant than bolls for at least 60 days after fruiting begins. Bolls, however, carry the immature weevils through unfavorable seasons because of their retarding effect on development and their resistance to unfavorable temperature and humidity. When climatic conditions are unfavorable to the weevils, the proportion of bolls to squares tends to be greater than under favorable conditions.

At present it is not possible to predict from weather records, with any certainty, increase of weevils, largely owing to variations in the characters of the plants themselves. Both air and soil temperature and relative humidity are modified by shade, and this becomes increasingly important as the season advances. Drought is the most important factor in checking weevil outbreaks, excessively high summer temperatures and poor development of squares being associated with it.

1936 - Smith, G. L., and M. T. Young. Field movement of boll weevils in relation to initial infestation and rainfall. J. Econ. Ent. 29(6):1063-1066.

The numbers of boll weevils taken on adhesive screens in 9 cotton fields in northeastern Louisiana during 1933, 1934, and 1935 were positively correlated with the total rainfall during June, July, and August and with the number of days with 0.3 in. or more rainfall during those months. In each year, there was a high and fairly uniform infestation by overwintered weevils during May and early in June. Infestation was higher in 1934 than in 1933 or 1935. The catch of weevils on screens in June 1933, 1934, and 1935 was 64, 102, and 27, respectively. In June, July, and August of 1933, 1934, and 1935, the total rainfall was 18.46, 11.23, and 6.89 in. Three-tenth of an inch of rain or more fell on 14, 9, and 5 days, respectively.

The catch of weevils on screens from June to November was 5,232 in 1933, 2,573 in 1934, and 369 in 1935. This decrease is shown graphically to be almost directly proportionate to the decrease in the number of days on which rainfall was 0.3 in. or over, and to bear nearly as a direct relation to the total rainfall during the 3 months. Of the total rainfall and days with 0.3 in. or more during June, July, and August, more than 50% occurred in July in 1933, and in June 1934 and 1935. The number of weevils caught in September 1933 was higher than in August of the same year, but in 1934 and 1935 the catches for September were much lower than in August. Heavy catches in November 1933, October and November 1934, and October 1935 were due to the flights of the weevils seeking hibernation quarters, which occurred at different times on account of varying climatic conditions and other factors.

1936 - Smith, G. L. Percentages and causes of mortality of boll weevil stages within the squares. J. Econ. Ent. 29(1):99-105.

During the cotton fruiting season, 1929-31, inclusive, fallen squares and flared and damaged squares hanging on the plants were collected at about 15-day intervals in June, July, and August from 8 fields in Louisiana representing different soil types. Examination of this material showed the percentage mortalities of all stages of the boll weevil in hanging squares to be 4.3% in 1929, 12.06% in 1930, 9.24% in 1931, and 11.63% in 1932. The corresponding percentages for fallen squares were 11.42%, 41.33%, 15.33%, and 24.08%.

Temperature is the most important element in the climatic factor and has the greatest effect on squares on the ground, exposed to the sun. The effective fatal maximum temperatures lie from 93°F. upward, varying in efficiency almost directly with increase above that figure. A single day much above 95°F. is sufficient to produce heavy mortality in stages in contact with the earth and fairly exposed to the action of the sun. With rainfall much less than $1\frac{1}{2}$ inches over the 15-day period, mortality was likely to be high, whereas precipitation in excess of that amount tended to reduce mortality. This correlation is not thought, however, to be direct, but to be due to the effect of moisture upon temperature.

1943 - Gaines, R. C. Relation between winter temperatures, boll weevil survival, summer rainfall, and cotton yields. J. Econ. Ent. 36(1):82-84.

Although the records were few, the number of boll weevils found in woods trash was associated with the number of boll weevils found in cotton fields during the following May and June. Since the correlations between winter temperatures and the number of weevils in cotton fields during May and June were significant, the inference would be that ground trash affords an important shelter for the weevils during the winter.

Control of the boll weevil by effective dusting was reflected in the percentage increase in yield in the experimental plots with both yield per planted acre and total yield in Madison Parish.

1953 - Gaines, R. C. Relation between winter temperatures, boll weevil survival, summer rainfall, and cotton yields. Assoc. South. Agr. Workers Proc. 50:114.

Correlation studies were made of various records of weather, survival of boll weevils in different shelters, weevils found in cotton fields in May and June, summer rainfall, and cotton yields in Madison Parish, Louisiana, from 1915 to 1952, inclusive. Of all the records included in these studies, boll weevil survival records as either the number found in woods trash in February and March or as the number found in cotton fields in May and June, and summer rainfall recorded as number of days with 0.30 inch or more from June 21 to August 19 had the greatest influence on boll weevil injury, recorded as percentage increase in yield in experimental plots where weevils were controlled with insecticides. Summer rainfall from June 21 to August 19, recorded as total or as number of days with 0.30 inch or more, had great influence on total yield of cotton in Madison Parish.

1953 - Gaines, R. C. Relation between winter temperatures, boll weevil survival, summer rainfall, and cotton yields. J. Econ. Ent. 46(4):685-688.

Correlations were found between:

1. Winter temperatures and boll weevil survival.
2. Overwintering boll weevils and cotton yields in tested plots.
3. Overwintering boll weevils, summer rainfall, and increased yields in treated plots.

1956 - Warren, L. O., Gordon Barnes, T. F. Leigh, H. A. Turney, and Charles Lincoln. Rate of acceleration of boll weevil (<u>Anthonomus grandis</u>) in Arkansas during 1954 and 1955. Assoc. South. Agr. Workers Proc., 53:151.

Boll weevil infestations in Arkansas during 1955 were influenced to a great extent by the better moisture conditions prevalent in June and early in July. Infestations in 1954 were depressed in July and early in August due to the lack of a favorable moisture supply during the month of June.

HIBERNATION

1905 - Sanderson, E. D. Some observations on the cotton boll weevil. U. S. D. A. Bur. Ent. B. 52:29-42.

Hibernation of the weevil, including observations on time of entrance into hibernation, emergence from hibernation, and mortality during hibernation. The relation of climatic conditions to hibernation is discussed at some length. The rate of increase of weevils in the fields during the summer is discussed. A general discussion of the futile use of Paris green as a remedy is presented. Emphasis is given to the necessity of fall destruction of the cotton stalks in order to combat the pest.

1907 - Hunter, W. D. Boll weevil prospects for 1907. Farm & Ranch 26:7. Apr. 13.

Statement that the winter of 1906-07 was unusually favorable for successful hibernation of the weevil. The necessity for applying cultural control methods is emphasized.

1907 - Sanderson, E. D. Hibernation and development of the cotton-boll weevil. U. S. D. A. Bur. Ent. B. 63:1-38, 6 fig.

Since many cotton boll weevils die during hibernation, it was thought wise to study the effects of various conditions during hibernation upon the mortality of the weevil. It appears that the weevils cannot be forced into hibernation until the mean average temperature drops below 60°F. If, therefore, the weevils are deprived of food during the fall, the percentage of mortality among them may be greatly increased.

The cotton worm is considered of some benefit in this regard, since its chief attack is made upon the cotton plant late in the season, thus destroying the leaves and other edible parts upon which the weevils might otherwise feed. The same result may be brought about by cattle grazing.

The mortality of cotton boll weevils during hibernation is so great in some instances that not more than $2\frac{1}{2}$% to 15% survive. The maximum rate of mortality in weevils occurs in Dec. or Jan. and is increased by large rainfalls.

The emergence of the maximum number of weevils takes place in Texas from May 20 to June 1. Notes are given on various other points in the biology of the cotton boll weevil, including summer broods, rate of increase, injury to cotton squares, etc. The relation of temperature and other weather conditions to the hibernation of the insect is given special attention.

1909 - Hinds, W. E., and W. W. Yothers. Hibernation of the Mexican cotton boll weevil. U. S. D. A. Bur. Ent. B. 77:106, 10 pl., 9 fig.

A detailed report of extensive investigations of the hibernation of the cotton boll weevil conducted from 1902 to 1907 in Texas and Louisiana. The first part of the bulletin (p. 11-25) discusses the entrance of the weevils into hibernation. Shelter during hibernation is discussed at some length.

1910 - Newell, W., and M. S. Dougherty. The hibernation of the boll weevil in central Louisiana. La. Crop Pest Comn. C. 31:163-219, 1 pl., 5 fig.

An investigation of the hibernation of the boll weevil extending from September 15, 1908, to July 15, 1909, and conducted at Mansura, Anoyelles Parish, La., is reported in detail. The results and conclusions are summarized:

Out of 16,281 adult boll weevils confined in 16 cages, 3,360, or 20.63%, lived throughout the winter successfully. Destruction of all cotton plants before October 15 resulted in only 3% of the weevils surviving the winter. Letting the cotton plants stand in the field until about Christmas resulted in over 40% of the weevils living through the winter to attack the next crop. Starvation of the boll weevils before they entered hibernation in the fall was more effective in causing their death than was cold or wet weather during winter. The average time that the weevil remained in hibernation was 159 days. The extreme length of time that any weevil lived without food while in hibernation was 255 days, or $8\frac{1}{2}$ months. When the cotton plants are allowed to stand in the fields until killed by cold, the average weevil has to go without food only about 90 days. When cotton plants are destroyed before October 12, the average weevil must go over 6 months without food or starve to death. Early destruction of the cotton plants results in starvation of hordes of boll weevils.

Spanish moss sheltered an enormous number of boll weevils during the winter. Of the weevils that spent the winter in Spanish moss, 38% survived. Of those hibernating in average materials, only 20% lived. Boll weevils passing the winter in moss emerged from hibernation much later than those hibernating in other materials. Moss-covered trees near the cotton fields increase weevil infestation. The length of time that the weevils live after leaving hibernation in spring has an important bearing on the problems of poisoning the weevil and of when to plant the crop to best advantage. The average overwintering boll weevil lived 10.7 days after leaving winter quarters. The maximum length of life after leaving hibernation was 44 days.

The authors consider these results to be indicative of the weevils' hibernating habits in most of the alluvial territory in the Mississippi, Red River, Black River, and Ouachita valleys of Louisiana, as Mansura has practically the same prevailing temperatures, elevation, and rainfall.

1911 - Rosenfeld, A. H. Insects and spiders in Spanish moss. J. Econ. Ent. 4(4):398-409.
Contains records of Anthonomus grandis hibernating in ordinary Spanish moss, Tillandsia usneoides. An average of 1,313 weevils were found per ton of moss.

1912 - Hunter, W. D., and W. D. Pierce. The Mexican boll weevil: A summary of the investigations of this insect up to December 31, 1911. Sen. Doc. 305, 188 p.
Considerable detail is devoted to the hibernation habits of the weevil.

1921 - Smith, G. D. Studies in the biology of the Mexican cotton boll weevil on short-staple upland, long-staple upland, and Sea-Island cottons. U. S. D. A. B. 926, 44 p. Apr. 19.
A report of studies conducted at Madison, Fla., during 1918 and 1919. Considerable attention was devoted to longevity, oviposition, and hibernation. Differences in boll weevils bred on the different cottons are mentioned.

1925 - Hinds, W. E. Boll weevil control. La. Agr. Expt. Sta. Ann. Rpt. of La. State U. and A&M Coll.
Hibernation tests started in the fall of 1924 included 1,956 weevils placed in cages between October 4 and 15. Of these, only one weevil, or 0.005%, emerged the following spring, on May 15. Among 5,370 weevils placed in cages from October 31 to November 29, 1924, 483 weevils, or about 9%, survived. Weevils began to leave winter quarters in the cages by the middle of February, before cotton was planted. The peak of the emergence movement occurred during the last week of April, and the last weevil appeared on June 12. The percent of survival was unusually high and indicated a serious degree of attack on the 1925 cotton crop in the vicinity of Baton Rouge.

1927 - Fenton, F. A., and E. W. Dunnam. Winter survival of the cotton boll weevil at Florence, S. C. J. Econ. Ent. 20(2):327-336.
From 1922 to 1926, an average of 3.27 percent of cotton boll weevils survived the winter in various types of protective shelters at Florence, S. C. Practically all weevils issuing from hibernation before cotton was available as a food plant died, the average longevity at this time being 5.64 days.
Weevils emerging from winter quarters after cotton came up were placed in field cages on young plants. A great majority of them died before the plants started to square. Average longevity under these conditions was 8.12 days. Weevils emerging at or after the time when squares were developed on cotton plants were longer lived in these same field cages than those emerging prior to development. The average longevity for males was 16.28 and for females, 13.42 days. The maximum longevity at this time was 66 days for males and 46 for females. According to trap crop records and field counts, weevils continued to enter the cotton fields for 3 to 4 weeks after the first squares formed, or until about the time the first blooms appeared.
In 1925, 90.01% of the surviving weevils had emerged in all cages at the time cotton began to square, 73.04% in those in the woods, 90.37% in those in the field, and 47.01% in the trap crops. Emergence in the hibernation cages located in the woods corresponded very closely with that in the two trap crops after May 14.
In 1926, 98.03% of the weevils had emerged in all the hibernation cages when cotton began to square, all in those in the woods, 97.91% in those in the field, and none had been collected in the trap crops. The emergence of the weevils in the hibernation cages is called the "total emergence," and that in the trap crops the "effective emergence," since the latter represents those weevils that emerge late enough to find cotton.
Trap-crop records and field counts for the 2 years indicated that there may be a considerable migration of weevils to cotton fields after first square production, although this may actually represent a small percentage of the total survival for that year. The use of the trap crop in determining the rate of "effective emergence" of the weevil from hibernation is more reliable and more representative of field conditions than is that of the hibernation cage.

1929 - Baerg, W. J., D. Isely, and H. H. Schwardt. Report on entomological work 1928-29. Ark. Agr. Expt. Sta. B. 246:50-53.

Serious annual injury to cotton by the boll weevil occurs over a comparatively small area during the growing season. The damage caused after the weevils disperse late in the summer is usually relatively light under average conditions. Some localities are subject to sporadic outbreaks in certain years.

The weevil regularly occurs in fertile land, bordered by well-drained hill land favorable for hibernation. In such land, the plants usually form squares late in the season, in which the weevils are able to reproduce in large numbers before going into hibernation, and direct control is advisable.

Although sandy hills are ideal hibernating quarters, the number of weevils that develop to go into hibernation is often comparatively small, since a drought late in the summer and autumn often checks the setting of the squares on cotton grown on light soil. Even when large numbers hibernate and a heavy infestation occurs early in summer, a period of hot dry weather may stop an infestation that appears to be well under way.

On flat lands that are not well drained in winter, the weevils do not hibernate successfully except on knolls, etc. If the areas that require winter cleaning are not large, control of the weevil by destroying it in hibernation is recommended.

1929 - Fenton, F. A., and E. W. Dunnam. Biology of the cotton boll weevil at Florence, S. C. U. S. D. A. Tech. B. 112, 75 p.

The average winter survival during 4 years' observation was 3.27%. The best protection was given by piled cotton stalks. Other shelters, in the order of their importance, are corn stalks, pine straw, Spanish moss, sawdust or shavings, and oat straw. There was a definite relation between rate of emergence from hibernation and type of shelter; weevils in pine straw, corn stalks and Spanish moss continue to emerge later than those in other shelters.

Migration to cotton after emergence occurred from mid-May to late in June in 1925. Weevils emerging before cotton came up in 1925 and 1926 sometimes remained active in cages for several days or again entered hibernation. A few weevils began to hibernate early in September and most of them did so late in September and October.

1929 - Isely, Dwight. Ark. Agr. Expt. Sta. 41st Ann. Rpt. B. 246: 51-52. Dec.

Most regular occurrence of boll weevil in destructive numbers is in fields on fertile land, bordered by well-drained hill land favorable for hibernation of the weevil. On flat lands, not well drained in winter, the boll weevil does not hibernate successfully.

1931 - Calhoun, P. W. A correlation of the date of emergence and percentage of survival of the cotton boll weevil with the date of their installation in hibernation cages. Fla. Ent. 15(3):41-48.

To determine the effect that the date of confining Anthonomus grandis Boh. in hibernation cages in the autumn might have on the date of their emergence or the percentage of their survival, the data from 11 groups of hibernation cage experiments in Florida and 1 in Mansura, La. were examined. In 9 groups of cages, placed either on the ground in open fields, or on the ground or in trees in woods, the date of confining the weevils in the autumn apparently did not determine to any considerable extent the date of their emergence in the following spring, but, in 5 groups on the ground in open fields, the date had a marked effect on the percentage of emergence. The highest percentages of survival always came from cages in which the weevils were introduced moderately late in the autumn. In 4 groups of cages placed in trees in woods, the date of confinement in the autumn seemed only slightly to affect the percentage of survival.

This, however, should not be interpreted to mean that the destruction of the green cotton stalks early in the autumn would prove of little benefit in localities where weevils are supposed to hibernate largely in mossy trees. Early stalk destruction greatly reduces the number that hibernate. Moreover, as cage hibernation tests have been found unreliable as a means of predicting the time of appearance of boll weevils in the cotton fields, it would be unsafe to conclude that

destroying the stalks at different dates would have the same effect on the mortality of the overwintering weevils.

1931 - Grossman, E. F. Hibernation of the cotton boll weevil under controlled temperature and humidity. Fla. Agr. Expt. Sta. B. 240, 19 p.

The correlation of temperature and humidity with the emergence from hibernation of Anthonomus grandis Boh. being difficult to determine from field or hibernation cage data, a study was undertaken in which uniform temperatures and relative humidity were maintained in artificial hibernation quarters for boll weevils. The technique employed in the experiments is described. A study of the longevity of the weevils is shown in tables. Combined with hibernation cage data, it indicates the possibility of a prolonged period during which the hibernated boll weevil can enter and infest a cotton field.

About 125,000 weevils were used in the experiments, in temperatures maintained at 47°F., 60°F., and 81°F., with a relative humidity between 79% and 85%. After 170 days, 20% of 32,000 weevils were living; after 206 days, 15%; and after 236 days, 10%. Approximately 0.6% lived 300 days, indicating that when hibernation conditions are favorable, 1 weevil out of each 200 to enter hibernation on October 1st could live long enough to emerge from hibernation on August 1st of the following year. Or, entering on November 1st, they could emerge on September 1st, though, as a matter of fact, that majority invaded the cotton fields during June. At 47°F., increased mortality was observed during the first month of dormancy and again after a period of several months of a low rate of mortality. The destruction of cotton stalks immediately after harvest not only reduces breeding but also prevents the weevil already in the field from feeding enough to withstand an extended period of hibernation.

1931 - Grossman, E. F. Winter survival of immature stages of the boll weevil. Fla. Ent. 15(1):13-14.

Field and laboratory investigations in 1927 and 1928 indicate that in Florida the larvae of Anthonomus grandis Boh. in cotton squares and bolls probably fail to develop into adults during the winter months. Though individuals in the late pupal stage in squares and bolls may do so, the toughness of the overwintered bolls generally tends to prevent their emergence. Abandoned cotton stalks should, however, be destroyed early in the autumn, as they provide favorable hibernation quarters for the adult weevils.

1931 - Grossman, E. F., and P. W. Calhoun. Determination of the winter survival of the cotton boll weevil by field counts. Fla. Agr. Expt. Sta. B. 233, 47 p.

During several years' observations in Florida, data obtained from hibernation cages on the winter survival of Anthonomus grandis Boh. and on its period of emergence were very inconsistent. They failed to show a seasonal uniformity of emergence under the same weather conditions as occurred in field tests. Data from field counts were uniform; each year's results corresponded with those of the previous or following years. Field counts conducted in 5 different localities in the State also gave uniform results.

The time of appearance of the weevils rarely extended over a period of 30 days, whereas that in hibernation cages lasted over a period of 5 months. The peak of emergence in the field extended from June 3d to the 20th, whereas in the cages it occurred from March 5th to June 2d. The appearance of the weevils in the field seems to be dependent on temperature conditions during May and June, regardless of the conditions prior to that time. Field counts indicate the percentage of survival and degree of infestation that can be expected from year to year, and from these observations it appears that the weevils enter cotton fields in infested areas during June.

1931 - Rude, C. S. Cotton boll weevil has no hibernation in Laguna District of Mexico. J. Econ. Ent. 24(3):761-762.

In a district of north-central Mexico, a newly emerged adult of Anthonomus grandis Boh. was found on February 17th among cotton bolls picked the preceding autumn. Three live pupae were also discovered while dry cotton bolls were being cut open on February 28th, and 2 old weevils were taken on March 16th

from a flight screen in a field where cotton stubble had been plowed under about a month previously.

These facts indicate that A. grandis does not hibernate in this part of Mexico, which is a desert plateau about 3,700 ft. above sea level where cotton is raised by means of irrigation. Annual rainfall is less than 9 inches.

1932 - Cartwright, O. L. Insect pests and related matters. S. C. Expt. Sta. 1931-32 Rpt. 45:65-79.

More adults of the cotton weevil emerged from hibernation in cages placed in a sheltered ravine than in those in an exposed situation on a hill, and oak leaves and pine needles gave better protection in the cages than maize stalks. An average of 11.6% of all the weevils placed in the cages in October 1931 emerged.

1934 - Cartwright, O. L. Entomology. S. C. Expt. Sta. 1933-34, Rpt. 47:56-64.

"Cotton boll weevils (Anthonomus grandis Boh.) placed in cages in 1933, 2.53% survived in winter and emerged between 9th April and 5th July 1934. More adults emerged from hibernation in cages placed in an exposed situation on a hill than in those in a sheltered ravine.

"As a result of the combined attack of A. grandis and P. seriatus, little fruit was set on the upper third of the cotton plants in one locality."

1935 - Gaines, R. C. Cotton boll weevil survival and emergence in hibernation cages in Louisiana. U. S. D. A. Tech. B. 486, 28 p.

A study of the hibernation of Anthonomus grandis Boh. was carried out at Tallulah, La., over the 15-year period 1915-16 to 1930-31, with the exception of the winter of 1926-27, and in 17 cooperating laboratories in various States during the last 7 years of the investigation. The tests were made in screen wire cages of a uniform size. A standard procedure, which is described, was followed throughout, one variable being introduced into each series of tests.

The average winter survival for the whole period under all cage conditions at Tallulah was 1.22%. The percentages at most of the other stations were higher because more favorable shelters were used and more of the weevils were placed in the cages after October 6th. The figures that follow were obtained at Tallulah.

In a study of the effect of time of entering hibernation, the highest survival (2.55% to 2.92%) was among weevils placed in cages between October 20th and November 18th. None of those placed in cages before September 7th survived.

Among various materials provided for shelter, the highest survivals occurred in maize stalks (1.99%), followed by Spanish moss (1.66%), Spanish moss and cotton stalks (1.44%), sawmill debris (1.36%), and oat straw (1.34%). A much lower rate of survival occurred in a number of other materials and combinations. During the winters of 1925-26 onwards, the percentage surviving in Spanish moss was 0.57% in cages placed under standing timber and 0.88% in an open field.

In a study of the relation of survival to winter weather conditions, the only significant correlations were with minimum temperatures. Coefficients of correlation between survival and the number of times the temperature fell below 32°, 30°, 24°, 22°, 20°, and 18°F., respectively, were found to be significant. Those between survival and the number of times the temperature ranged from 18° to 20° and from 1° to 17°F., and that between survival and the minimum temperature for the winter were also significant. The weighted average percentage for the 4 years that the minimum temperature was 20°F., or higher, was 3.96%, as compared with 0.29% for the remaining years. Of the total number of weevils surviving, 15.7% emerged in March, 22.9% in April, 39.7% in May, 21.4% in June, and 0.3% in July. The emergence period for the different years ranged from 47 to 127 days, with a weighted average of 117 days. The extremely short period of emergence was during the years of very low survival. Emergence extended into July in only 4 years.

1935 - Gaines, R. C. Boll weevil activity during normal hibernation period at Tallulah, La. J. Econ. Ent. 29(6):1096-1099, 1 fig., 2 ref.

Observations made in Louisiana, from December 21 to the end of February during 6 winters, on the relation between temperature and the activity of adults of the boll weevil hibernating in cages.

Records were made almost daily, and the maximum temperature on the day of record was taken to be the temperature affecting activity. One weevil was found active on a day when the maximum temperature was only 36°F., but all others were found when the temperature was 40° or higher.

The percent of weevils recorded as active at maximum temperatures of 36° to 45°, 46° to 55°, 56° to 65°, 66° to 75°, and 76° to 81°F. were 1%, 7.6%, 20.1%, 36.9%, and 34.4%, respectively. The average numbers of weevils found to be active each day at those temperatures were 5.5, 9.5, 18.7, 23, and 62.7. The number of weevils found to be active during the period of hibernation was 2.65% of the total number in the cages, but it is probable that some weevils died before the end of February, thus reducing the total number that might become active.

Examination of adhesive screens, situated in infested cotton fields during the hibernation periods of the years 1931-35, indicated that there was no flight at maximum temperatures of 62° to 65°, 66° to 67°, and 67° to 83°F., respectively.

1935 - Hixson, E. Distribution of hibernated boll weevils in an Oklahoma cotton field. J. Econ. Ent. 29(1):96-99.

Distribution of overwintered boll weevils (Anthonomus grandis Boh.) in a heavily infested cotton field in southeastern Oklahoma, late in May and early in June 1934, showed no relationship to nearness of adjacent woods. The weevils did, however, tend to be more numerous in that part of the field nearest alfalfa, and this tendency increased noticeably in the later examinations. Statistical analysis showed a high degree of negative correlation between weevil population and increase in distance from the alfalfa field.

1935 - Hixson, E., and C. A. Sooter. Freezing temperatures of the chinch bug, Blissus leucopterus, Say. J. Econ. Ent. 29(2):465-466.

B. leucopterus had a mean freezing point of 9°F. for February and 17.5°F. for March, compared with 10° and 15°F. on corresponding dates for Anthonomus grandis Boh., which emerge from hibernation in Oklahoma in June. The chinch bug emerged in April.

1937 - Hixson, E., and C. A. Sooter. Temperatures at which boll weevils freeze. J. Econ. Ent. 30(6):833-836.

The cotton boll weevil is much more resistant to cold than was formerly supposed. The undercooling temperatures of 991 boll weevils show a range from 26.6° to 9.4°F. Those undercooled in November and February were the most resistant, while those undercooled in December and March were the least resistant. Winters having low minimum temperatures were followed by small field populations of hibernated weevils, whether the population the previous year was large or small.

1941 - Reinhard, H. J. Cotton insect investigations. Tex. Agr. Expt. Sta. 54:31.

An unusually mild winter season from November 1940-January 1941 (minimum temperature 26°F.) followed by the heaviest boll weevil survival recorded at College Station. Out of a total of 5,000 weevils installed in hibernation cages, 951, or 19.2%, passed the winter successfully. Total weevil emergence from hibernation by months in 1941 was as follows: April, 3.6%; May, 9.4%; June, 5.7%; July, 0.4%. In the period 1936 to 1941, inclusive, the average boll weevil survival was 7.4%.

1942 - Bondy, F. F., and C. F. Rainwater. Boll weevil hibernation, survival, and emergence under South Carolina conditions. J. Econ. Ent. 35(4):495-498.

Studies on the factors that influence the abundance of Anthonomus grandis Boh. on cotton, with particular reference to survival of the winter and emergence in South Carolina. In cage tests carried out in 1931-41, only a small proportion survived even the mildest winter. Temperature was the most important factor affecting survival, which averaged 0.21% in 4 years when the minimum temperature was below 15°F. and 5.67% for 5 years when it was 19°F. or above.

The numbers of weevils that survived in cages were considerably higher in trash from the woods, and lower in maize stalks than in Spanish moss, and higher in cages in the woods than in those in the open fields. The average survival of weevils placed in the cages in the open field on November 15th was more than twice that of those installed on October 15th, showing the value of early destruction of cotton stalks. It compells the weevils to enter hibernation early and in a weakened condition owing to lack of food.

Spanish moss hanging from the branches of trees near cotton fields from 1928 to 1938 was regularly examined each autumn to determine the relative number of weevils that hibernated in it. It was examined each spring to find the proportion of weevils that survived the winters. Comparatively large numbers hibernated, and temperature was an important factor affecting survival. Of weevils found in the moss in spring, 70.2% and 0% were alive after winters with lowest minimum temperatures of 23° and 2°F., respectively. In systematic examinations begun in 1937-38 to determine the number of weevils hibernating in trash in woods, 78% of the weevils found were within 50 ft. of the edges of woods bordering cotton fields and practically none more than 150 ft. from the edges, indicating the usefulness of burning large areas of woods for weevil control.

It is considered that correlating the results will give a more reliable index of probable abundance than was obtained from examinations of Spanish moss. A study of the period when weevils emerged from natural hibernation and entered the cotton fields was made each year from 1938 in an isolated trap plot of early planted cotton. Each plant was examined at least 3 times a week from the time the cotton was large enough for weevils to feed on until July 1. Every weevil was counted and killed, and every square that formed was removed so that no new weevils could develop. Approximately 88% of the total emergence occurred in June; about 46%, in the second half of the month. Mopping the cotton with sweetened poison is not effective control after squares are large enough for the insects to feed on. Since such squares are usually available by June 15 in this district, and a large emergence occurs later, this method of control is quite unreliable.

1943 - Reinhard, H. J. Hibernation of the boll weevil. Tex. Agr. Expt. Sta. B. 638. Aug.

Weevils do not enter true hibernation when they first seek fall shelter. They may remain more or less active during warm spells in the winter and may leave sheltered areas.

Among factors influencing the extent of weevil mortality, minimum temperature was most important. From 6% to 19% of the population survived when minimum was not below 25°F. When minimum ranged from 17° to 0° F., less than 2% survived. The average survival at College Station (1925-1942) was 6.04%. Mortality among weevils caged prior to October 15 was nearly 3 times greater than that recorded for installations made at subsequent dates. Emergence begins when temperatures reach 55° to 60°F. After emergence is definitely under way, rainfall has important influence on the rate at which boll weevils leave shelter. Frequent well distributed showers followed by warm sunshine favor maximum emergence. During the 18-year period, 50% emerged by May 15.

Percentage of weevil survival has no direct relation to extent of plant injury.

1950 - Bondy, Floyd F., L. C. Fife, R. L. Walker, and C. E. Jernigan. Boll weevil emergence from hibernation. S.C. Agr. Expt. Sta. 63d Ann. Rpt., 72 p. Dec.

Over a 12-year period, approximately 1/4 of the weevils emerged from hibernation before June 1, or before the fruiting of the cotton plant; 3/4 emerged after June 1, or after squaring of the cotton plant began; and 1/3 emerged after June 14, or after blooming began. Therefore, 3 early season applications of insecticide at 7-day intervals, beginning at squaring or 7 days after squaring, will not kill all the overwintering adults. For this reason, it is likely that 3 or 4 additional applications of any insecticide will be necessary for good seasonal control.

1950 - Fife, L. C., R. L. Walker, and C. E. Jernigan. Examinations of woods trash indicate potential damage by boll weevil in 1950. S.C. Agr. Expt. Sta. 63:94-95. Dec.

In the fall of 1949, an examination of surface trash collected from woods adjacent to cotton fields on 20 farms in Florence County indicated that boll weevils had entered hibernation at the record-breaking rate of 10,744 per acre. The previous high record of weevils entering hibernation was 4,840 per acre in the fall of 1945. The winter of 1949-50 was mild, with an average temperature of 52.4°F. and a minimum of 25°F. for November through February. The examination of surface trash in March 1950 disclosed the presence of 11,108 weevils per acre. The previous high for weevil survival in Florence County was 3,969 per acre in March 1949.

The lowest winter survival of the boll weevil on record at Florence was 176 weevils per acre in March 1940. During the winter of 1939-40 the mean temperature was 44.6°F. for November through February, and the minimum was 13°F. Damage to the cotton crop that year was considerably below average.

Although the winter survival is important, the damage caused by the boll weevil is largely governed by weather conditions during June, July, and August. With maximum temperatures below 95°F. and with frequent showers and cloudy weather during these months, considerable boll weevil damage to the cotton crop will result even though the winter survival is low.

1950 - Fife, L. C., R. L. Walker, and C. E. Jernigan. Most boll weevil enter cotton fields in June. S.C. Agr. Expt. Sta. 63rd Ann. Rpt., p. 95. Dec.

Although the records from hibernation cages and surface trash examinations serve as a fairly reliable test of boll weevil survival, they do not show when weevils return to cotton fields under natural conditions. Weevils in cages, especially in the open field, were found to emerge much earlier than weevils in natural hibernation.

A study was begun in 1938, on an isolated trap plot of early planted cotton, showing periods when weevils emerged from natural hibernation and entered the cotton fields. This planting has been continued each year since 1938 on the same 1/5-acre plot. Each plant was examined at least 3 times a week from the time the cotton was large enough for weevils to feed on until July 1. All weevils found were counted and killed, and every square that formed on these plants during this period was removed so that no new weevils could develop.

For the period 1938-50 an average of 27% of the weevils emerged before June 1 or before the fruiting of the plant. The other 73% of the boll weevils emerged in June, or after the squares began to form; and an average of 33% of the weevils emerged after June 14, or after blooming began. Since the overwintering generation of weevils emerged through June and the first brood begins to emerge about June 15, 3 applications of an insecticide, at weekly intervals, beginning at squaring, and 3 at blooming have been recommended for early season control of boll weevils.

1952 - Beckham, C. M., and M. Dupree. Boll weevil hibernation in Georgia in 1951-52. Cotton Gin and Oil Mill Press 53(9):43-44.

According to spring counts 75% of the weevils that went into hibernation in 4 counties in Georgia survived the mild winter.

1957 - Beckham, C. M. Hibernation sites of the boll weevil in relation to a small Georgia Piedmont cotton field. J. Econ. Ent. 50(6):833-834.

The average number of weevils found per acre in the different habitats and the distance from an old cotton field are shown in a table. Examinations of the different types of habitats showed that this insect overwintered in largest numbers in surface woods trash near the old cotton fields. The largest number of weevils was found in pine straw and leaves in the woods about 50 feet from the edge of an old field. Considerably fewer weevils were found at distances of 150 feet and only a few at 250 feet. No weevils were found in a dense pine woods at a distance of 825 feet, indicating a short flight range when the weevil is seeking

hibernation quarters. Broomsedge was found to harbor only a few weevils 50 feet from an old cotton field and none at distances of 150 and 250 feet. Dead bermuda grass on a railroad bank fill apparently was not sufficiently dense to afford good protection as no weevils were found in this habitat at a distance of 50 feet from an old cotton field.

One interesting result of this study was the finding of live weevils in old cotton bolls remaining on the stalks in the field. Although the number of weevils found in the old bolls was low, in comparison with the counts in the surface woods trash, it may be an important point in favor of stalk destruction.

1958 - Fye, R. E., A. R. Hopkins, W. W. McMillian, and R. L. Walker. Survival and emergence of boll weevils from several areas under similar hibernating conditions. J. Econ. Ent. 51(5):745-746.

In November 1956, trash was collected from several areas in the Carolinas and Virginia and brought to Florence, S. C., for examination. All the weevils collected in each area were placed in an 8-inch cylindrical wire cage containing woods trash and put back in hibernation at Florence. On May 1 the small cages containing them were put inside 4-cubic-foot screen cages, the ends opened, and the weevils allowed to emerge. Results suggest that weevils entering hibernation in the northern area are conditioned to survive under more severe winter conditions than occurred at Florence. Weevils from South Carolina emerged much earlier than those from Virginia, the respective percentages on June 1 being approximately 90% and 30%. Emergence from the other areas was intermediate between these.

1959 - Fye, R. E., W. W. McMillian, R. L. Walker, and A. R. Hopkins. The distance into woods along a cotton field at which the boll weevil hibernates. J. Econ. Ent. 52(2):310-312.

A study of the distance that the boll weevil moves into woods adjoining cotton fields revealed that 90% hibernate in the first 180 feet. The most weevils were taken 30 to 45 feet into the woods. High populations were found in trash 1/2 to 3 inches deep, and more were found in deciduous leaf trash than in pine straw. More weevils were found in slightly moist trash than in exceedingly dry or wet material.

1959 - Walker, J. K., Jr., and J. R. Brazzel. A method for collecting diapausing boll weevils for hibernation studies. J. Econ. Ent. 52(2):346-347.

Twelve 4'x 4'x 4' wooden frame hibernation cages covered with 16-mesh screen wire used outside the laboratory at College Station, Tex. Fifty pounds of Spanish moss was suspended from the top of each cage. Ten cages were used to confine weevils which were collected from the field at 10 weekly periods from September 8 to November 4 and caged immediately, about 500 per cage. These weevils received no food after collection. Boll weevils in 2 cages were allowed to feed after collection on November 4 for 2 and 4 weeks in the laboratory before confinement. Only those weevils that had ceased feeding were transferred to the two cages. Emergence from the hibernation cages was recorded during April, May, and June of the following year. Sex ratios were determined. Of the weevils caged immediately, maximum emergence was 4% from the cage containing weevils collected on October 9. From the cages containing the weevils allowed to feed for 2 and 4 weeks, respectively, after collection on November 4, 19.3% and 13.8% emerged. The sex ratio of weevils emerging in April was 52.6% males and 47.4% females; for May, 60% males and 40% females. No emergence took place in June.

DIAPAUSE

1957 - Brazzel, J. R., L. D. Newsom, J. S. Roussel, and R. C. Gaines. The effect of food on fat accumulation of the boll weevil. Assoc. South Agr. Workers Proc. p. 54:145.

Boll weevil infested squares and bolls were collected from the St. Joseph and Baton Rouge, La. areas. Weevils obtained from the squares and bolls were

allowed to feed for varying lengths of time on squares, blooms, or bolls, Fat determinations were made by extracting the fat in Soxhlet apparatus with ethyl ether.

1959 - Brazzel, J. R., and L. D. Newsom. Diapause in Anthonomus grandis, Boh. J. Econ. Ent. 52(4):603-611.

Part of the boll weevil population enters diapause late in summer and early in fall in La. Winter is passed in this condition. Diapause in this insect is characterized by cessation of gametogenesis and atrophy of gonads, increase in fat content, decrease in water content, and decrease in respiratory rate.

Diapausing boll weevils were found in ground trash each month of the year except June and July. It is almost certain that they were also present there during these 2 months but no collections of ground trash were made at this time. Diapause occurred in some individuals as early as July 30, and movement to winter quarters began prior to August 16 during 1957.

Fat and water content remained relatively stable in diapausing weevils during late fall, winter, and early spring. There was a sharp decrease in fat and a corresponding increase in water content soon after they moved back to cotton in the spring.

Males were able to resume spermatogenesis prior to leaving their winter quarters but oogenesis did not begin until the females had fed on seedling cotton.

1959 - Brazzel, J. R. The effect of late-season applications of insecticides on diapausing boll weevils. J. Econ. Ent. 52(6):1042-1045.

Three insecticides were applied to cotton plants from August 22 through November 20, after the normal control program was completed, to determine the effect on diapausing boll weevil populations under caged conditions. Determination by dissection indicated relatively large numbers of weevils diapaused in the toxaphene and calcium arsenate treatments but only 1 diapaused in the plots treated with methyl parathion. These results indicated that properly timed late season insecticide applications, coordinated with cultural practices, may be effective in reduction of the overwintering boll weevil population.

1960 - Brazzel, J. R., and B. G. Hightower. A seasonal study of diapause, reproductive activity, and seasonal tolerance to insecticides in the boll weevil. J. Econ. Ent. 53(1):41-46.

A seasonal study of reproductive activity, incidence of diapause and seasonal tolerance to toxaphene and Guthion (O, O-dimethyl S-(4-oxo-3H-1,2,3,-benzotriazine-3-methyl) phosphorodithioate) in the boll weevil was conducted in 4 cotton fields in central Texas. Diapausing weevils were first found in the various fields from late July through August. Once diapausing weevils were found in a field, they occurred in all subsequent collections from the field.

Reproductive activity was high from June until the onset of diapause. One peak of reproductive activity occurred in September on regrowth cotton. Overwintered weevils that emerged early in the season with fat content over 10% of the dry weight were harder to kill with toxaphene than weevils of the current season collected during June and early July. Seasonal tolerance to toxaphene of up to 100-fold occurred with the onset of diapause in the populations. No evidence of seasonal tolerance to Guthion was found.

PHYSIOLOGY AND MORPHOLOGY

1916 - Blatchley, W. S., and C. W. Leng. Rhynchophora or weevils of northeastern America. p. 294. The Nature Publishing Co., Indianapolis, Ind.

Contains a description of an adult Anthonomus grandis.

1926 - Walker, H. W., and J. E. Mills. Progress report of work of the Chemical Warfare Service on the boll weevil. J. Econ. Ent. 19(4):600-601.

The average weight of a boll weevil is reported to be 16 milligrams.

1936 - Ting, P. C. The mouth parts of the Coleopterous group Rhynchophora. Microentomology v. 1(3):93-114. Aug. 13.
Includes a description of the mouth parts of Anthonomus grandis.

1938 - Sevingle, H. S. Relative toxicities to insects of acid lead arsenate, calcium arsenate and magnesium arsenate. J. Econ. Ent. 31(3):482.
pH of the mid-gut of the boll weevil reported as being 6.5.

1951 - Peterson, A. Larvae of insects. Part II. p. 98, 120, 122. Edwards Brothers, Inc., Ann Arbor, Mich.
Contains descriptions and drawings of Anthonomus grandis larvae.

1959 - Burke, Horace R. Morphology of the reproductive systems of the cotton boll weevil (Coleoptera Curculionidae). Ent. Soc. of Amer. Ann. Rpt. 52(3):287-294.
The genitalia and reproductive organs of the reproducing male and female cotton boll weevil are described and illustrated. Descriptions are given of the musculature associated with the reproductive systems of both sexes.

1960 - Thomas, John G., and J. R. Brazzel. An abnormal antennal condition in a resistant strain of the boll weevil. J. Econ. Ent. 53(4):688-689.
A male boll weevil, with an abnormal antennal condition, was mated with females to determine whether the abnormality could be used as a genetic marker. Results indicated that the character was a somatic mutation, was not genetically determined, or was the result of an extremely complex genetic mechanism.

1960 - Werner, F. G. A new character for the identification of the boll weevil and the Thurberia weevil (Coleoptera: Curculionidae). Ent. Soc. Amer. Ann. Rpt. 53(4):548-549. July.
The spermatheca of the female shows promise of providing a useful basis for identification.

RESISTANCE TO INSECTICIDES

1953 - Reiser, Raymond, D. S. Chadbourne, K. A. Kuiken, C. F. Rainwater, and E. E. Ivy. Variations in lipid content of the boll weevil and seasonal variation in its resistance to insecticides. J. Econ. Ent. 46(2):337-340.
1. The total lipid content of the boll weevil increases during the season from a low of about 7% in overwintered to a high of about 22% in October insects.
2. The fat content of the boll weevil is not directly related to its resistance to chlorinated hydrocarbon insecticides as indicated by
(a) increasing resistance to calcium arsenate during the season, and
(b) the higher fat content of insects resistant to any insecticide tested, or of surviving controls.
3. The relation of high lipid content to high resistance to toxaphene is not a universal quality in other insects.
4. It is suggested that the higher fat content, larger size, and increasing resistance of late season weevils may be due to the nutritional advantage of boll-reared over square-reared insects.

1954 - Ivy, E. E., and A. L. Scales. Are cotton insects becoming resistant to insecticides? J. Econ. Ent. 47(6):981-984.
No resistance was encountered in either bollworms or boll weevils. In the field cage tests approximately the same amount of DDT was required to kill bollworms as in the initial work 10 years ago. Approximately the same kill was obtained with 2, 1, or 0.5 pound of toxaphene as with the first sample tested in 1946.
With the boll weevil, the picture is slightly more complicated, because of its seasonal variation in susceptibility. In 1953, when tested against weevils reared in squares in June, both BHC and toxaphene showed about the same toxicity as when the initial work was done with these insecticides in 1945 and 1946. Late season tests conducted during 1953 also compare very closely with late season tests conducted in other years.

1955 - Roussel, J. S., and D. F. Clower. La. Agr. Expt. Sta. C. 41, 9 p.
Boll weevils became difficult to control in some areas of Louisiana late in the summer of 1954. Adverse climatic conditions, including high temperatures, high wind velocities, and low humidities, were considered responsible for the poor control obtained.
Under entirely different climatic conditions in 1955 even more difficulty was experienced in obtaining control. Work conducted in the laboratory, plus supporting work in the field, showed that a high degree of resistance to the chlorinated hydrocarbon insecticides had developed in boll weevil populations in some areas of Louisiana as follows: Northeast Louisiana to include Waterproof, St. Joseph, Tallulah, and large areas of East Carroll Parish; Ouachita River Valley south of Monroe; and Red River Valley, including parts of Caddo, Red River, Bossier, Grant, Natchitoches, and Rapides Parishes.

1956 - Roussel, J. S., R. V. Bielarski, and D. F. Clower. The status of chlorinated hydrocarbon resistance in the boll weevil in Louisiana. La. Agr. Expt. Sta., Dept. Ent. Spec. Release No. 1. July 5.
This report summarizes information obtained from topical treatments of Guthion and Endrin on overwintering boll weevil populations collected at several locations in Louisiana and on first generation boll weevils reared from infested squares collected in the same area. Results show that in areas where resistance to chlorinated hydrocarbons was high in 1955, it has persisted in 1956.

1956 - Walker, J. K. Jr., B. G. Hightower, R. L. Hanna, and D. F. Martin. Control of boll weevils resistant to chlorinated hydrocarbons. Tex. Agr. Expt. Sta. Prog. Rpt. 1902. Nov. 7.
Chlorinated hydrocarbon failed to give commercial control of boll weevil in several fields in the Brazos River Valley near Hearne in 1956. Calcium arsenate and several phosphorus compounds were effective in controlling these populations. Laboratory tests confirmed these differences.

1957 - Bielarski, R. V., J. S. Roussel, and D. F. Clower. Biological studies of boll weevils differing in susceptibility to the chlorinated hydrocarbon insecticides. J. Econ. Ent. 50(4):481-482.
Biological studies of 2 strains of the boll weevil, one quite susceptible and a second highly resistant to endrin, showed no difference in the average number of eggs produced per female per day, duration of larval stadia, pupal stage, or time required to develop from egg to adult. This is strong evidence that selection for resistance in the population was carried on independently of inheritance for other biological characters.

1957 - Brazzel, J. R., L. D. Newsom, J. S. Roussel, R. C. Gaines, and T. Cascio. The effect of food on fat accumulation of resistant and susceptible boll weevils. J. Econ. Ent. 50(4):459-462.
Fat content was determined for resistant and susceptible boll weevils reared in the laboratory and fed on blossoms, bolls, or squares. Fat content, as used in this study, was the total ether-extractable material expressed as a percentage of the dry weight of the boll weevils. Total fat and rate of accumulation by resistant and susceptible boll weevils were approximately equal throughout the feeding period. Unfed boll-reared boll weevils were fatter than unfed square-reared boll weevils and approximately the same difference in fat content was evident after feeding for 20 days. Both boll-reared and square-reared boll weevils accumulated more fat when fed bolls, less on blossoms, and least fat on squares.

1957 - Furr, R. E., E. P. Lloyd, and M. E. Merkl. Delta study of boll weevil resistance. Miss. Farm Res. 20(4):5. April.
1. There was a difference in kill with the same insecticide when weevils were obtained from different locations.
2. Mixtures of certain phosphate and chlorinated hydrocarbon insecticides gave better kill in field than either alone.

3. There was a difference in mortality from 5 pure compounds as the season progressed.

4. Phosphorus compounds were more effective than chlorinated hydrocarbon using topical applications.

1957 - Fye, R. E., R. L. Walker, and A. R. Hopkins. Susceptibility of the boll weevil in South Carolina to several insecticides. J. Econ. Ent. 50(5):700-701. bi-m.

Results from topical applications indicated a varying susceptibility of South Carolina boll weevils to chlorinated hydrocarbons. Median lethal doses of the insecticides used in boll weevil control correlated fairly well with recommended field dosages. Seasonal variations, nutritional and source differences, and differences in mode of action of the various insecticides were apparent.

One Darlington County location where large amounts of insecticides are used showed a high weevil resistance to endrin, but the area is still apparently well defined. Weevils with the greatest susceptibility to endrin were from Georgetown County where little insecticide is used. Little variation in susceptibility to Guthion was noted in weevils from various parts of South Carolina.

1957 - Hamner, A. L., and R. E. Hutchins. Boll weevil resistance to poison. Miss. Farm Res. 20(1):1, 5. Jan.

It was concluded that definite resistance exists to some degree, probably over relatively large areas in some parts of the State and perhaps on individual farms in other areas, particularly in the higher areas. Information indicates that resistant strains are associated with large numbers of applications each year over a period of years.

Field weevils were brought into the laboratory. Micro pipette was used for the measured drop method.

1957 - Roussel, J. S., and D. F. Clower. Resistance to the chlorinated hydrocarbon insecticides in the boll weevil. J. Econ. Ent. 50(4):463-468.

Results of studies conducted during 1955 and 1956 demonstrated that boll weevil populations resistant to the chlorinated hydrocarbon insecticides exist in Louisiana. Field experiments showed that resistance began to appear in 1953. It was determined that resistance was in the order of 100-fold and had persisted in the 1956 population. The fact that resistance persisted in 1956 would indicate that it is genetically controlled. A 2-fold vigor tolerance is demonstrated for Guthion. Some vigor tolerance is noted for calcium arsenate and Phosdrin in cage tests.

1958 - Tippins, H. H., J. J. Paul, L. W. Morgan, and C. M. Beckham. Results of laboratory studies on the toxicity of several insecticides to the boll weevil in Georgia. Ga. Agr. Expt. Sta., Mimeo Series, n.s. 53. March.

Field collected weevils were used. Topical applications were employed, using BHC and Guthion. Although differences in susceptibility between populations were shown, they were probably due to such factors as laboratory technique, collection date, or seasonal resistance. Differences were quite small, as compared with those of 100-fold as reported for chlorinated hydrocarbons by workers in other States. Where comparing percentage mortalities, the differences in susceptibility to Guthion were slightly larger than BHC in the work at Experiment.

1958 - Walker, J. K. Jr. Control of boll weevils resistant to chlorinated hydrocarbon insecticides. Tex. Agr. Expt. Sta., Prog. Rpt. 2009. Feb. 13.

Insecticide evaluations were made in 2 areas of the Brazos River Valley in 1957, one where weevils were reported as resistant and another area where resistance had not been found.

In the non-resistant area toxaphene-DDT was as effective as Guthion, methyl parathion and malathion. In the resistant area several organic phosphorus compounds, Sevin and calcium arsenate were more effective than toxaphene-DDT.

1958 - Young, M. R., and J. S. Roussel. The effects of temperature on the efficiency of insecticides applies topically to boll weevils differing in susceptibility to chlorinated hydrocarbon insecticides. J. Econ. Ent. 51(1):93-100.

Greater mortality of the boll weevil resulted at the higher, rather than at the lower, extreme of the post-treatment range of temperatures, with one exception--the response of the resistant strain to the endrin-malathion combination, wherein greater mortality resulted at the lower extreme of the temperature range.

The 2 strains (resistant and susceptible, or reference) differed greatly in their susceptibility to the chlorinated hydrocarbons. Toxaphene and endrin were ineffective against the resistant strain.

Endrin and malathion, when combined, were antagonistic at 90°F., but showed a synergistic effect of 60°F and 80°F. On the other hand, toxaphene and malathion combined were antagonistic at 60°F., but showed synergistic effect at 80° and 90°F.

The resistant and reference strains responded similarly to temperature changes for each insecticide used in respect to antagonistic or synergistic effects. These findings indicated that the mechanism which caused synergistic effect and antagonistic effect had differing temperature coefficients of action for the 2 combinations (endrin-malathion and toxaphene-malathion).

The fact that the same strain (either resistant or susceptible) responded differently to each of the 3 insecticides (endrin, toxaphene, and malathion) when held at different post-treatment temperatures, indicated that each insecticide had a different mode of action. The difference in the amount of insecticide required to control the reference strain as compared with the amount required to control the resistant strain, when held at varying post-treatment temperature levels, is further supporting evidence for such a conclusion.

This is the logical expectation in the case of malathion (an organic phosphate) and the chlorinated hydrocarbons as a group. However, it is noteworthy that endrin and toxaphene, both being chlorinated hydrocarbons, appeared to have different modes of action.

In addition to susceptibility to chlorinated hydrocarbon, there was an indication that the 2 strains differ in other physiological functions. The fact that more malathion was required to control the chlorinated-hydrocarbon-susceptible strain than was required to control the resistant strain prevents the assumption that the susceptibility to malathion and the susceptibility to endrin or toxaphene was controlled by the same mechanism.

It is also significant that although endrin was relatively non-toxic to the resistant strain, it still influenced the toxicity of malathion to this strain.

1959 - Blum, M. S., N. W. Earle, and J. S. Roussel. Absorption and metabolism of DDT in the boll weevil. J. Econ. Ent. 52(1):17-20.

The basis for the natural tolerance of the boll weevil for DDT was studied by treating weevils topically or by injection and determining the rate of penetration and metabolism of DDT. The weevil has a natural tolerance for DDT which varies with the strain, age, and time of year collected. Overwintered weevils are more sensitive than first-generation populations. Weevils resistant to chlorinated hydrocarbons, such as endrin, are slightly more resistant to DDT than endrin-susceptible weevils.

Both resistant and susceptible weevils are very susceptible to injected dosages of DDT. The rates of absorption in susceptible and resistant boll weevils are equal; about 60% of a 5 μg. dosage being absorbed in 48 hours. Small amounts of DDT are found in both strains, but slightly more in the susceptible insects. DDE is produced in trace quantities by both strains. After 48 hours about 40% of the applied DDT is converted into unknown metabolites. Neither DDE nor DDA is involved in the primary avenue of DDT detoxication. Compounds reported as outstanding DDT synergists in the house fly increase the toxicity of DDT in the weevil only 3- to 5-fold. DDT is more toxic to the weevil at lower temperatures.

1959 - Gaines, R. C., L. D. Newsom, J. S. Roussel, and N. W. Earle. Rearing and treating successive generations of boll weevils. J. Econ. Ent. 52(4):555-557. Aug.

In studies of boll weevil resistance to chlorinated hydrocarbon insecticides, 10 generations were reared from September 1956 to September 1958 and 4 to 6 generations were treated topically with insecticides. There was no indication of reversion to susceptibility in the untreated strains when tested with endrin. Endrin applied to resistant and susceptible strains increased the LD-50 and LD-90 and gave some changes in slope of lines. A mixture of equal parts of endrin and Guthion (O,O-dimethyl S-(4-oxo-3H-1,2,3,-benzotriazine-3 methyl) phosphorodithioate) and Guthion alone gave no changes in LD-50, LD-90, or slope. However, this does not prove that resistance will not develop with continued selection in large populations of boll weevils.

1959 - Roussel, J. S., M. S. Blum, and N. W. Earle. Joint action of DDT and other chlorinated hydrocarbon insecticides against resistant boll weevils. J. Econ. Ent., v. 52(3):403-409.

The joint action of DDT in combination with toxaphene, endrin, or lindane against boll weevils differing in susceptibility to the individual insecticides was studied in the laboratory. Weevils were treated topically or exposed to a residual film for mortality studies. These were either laboratory reared or field collected. Penetration and metabolism of DDT was studied when applied alone or in mixtures with other insecticides.

Mixtures of insecticides exhibited additive effects only for boll weevils susceptible to chlorinated hydrocarbon insecticides. However, when weevils resistant to these insecticides were used, the mixture of toxaphene-DDT exhibited synergistic effects. Mixtures of endrin-DDT and lindane-DDT exhibited additive effects only.

Penetration of DDT appeared to be equal for both strains. Separate applications of toxaphene and DDT to different sites of the weevil were as effective as a single application of the mixture. DDT applied as late as 96 hours subsequent to an application of toxaphene resulted in high mortality of weevils. However, repeated applications of toxaphene failed to give much of an increase in mortality.

Weevils did not metabolize DDT as rapidly when treated with the mixture as when treated with DDT alone. The metabolism of toxaphene is unknown. Although the toxaphene-DDT mixture exhibits synergistic activity against resistant boll weevils, the combination was not so effective against resistant boll weevils as toxaphene, alone, against susceptible boll weevils.

1960 - Burkhalter, G. F., and F. S. Arant. Boll weevil susceptibility to toxaphene, endrin, and Guthion in five Alabama localities. J. Econ. Ent., v. 53(2):311-313.

Laboratory experiments were conducted in 1956 and 1957 to determine the susceptibility of the boll weevil to toxaphene endrin, and Guthion (O, O-dimethyl S-(4-oxo-1,2,3,-benzotriazine-3-(4H)-ylmethyl) phosphorodithioate) in 5 Alabama localities. The technical insecticides were dissolved in acetone and applied topically to 2-day-old weevils reared from cotton squares. Mortalities were determined at the end of 72 hours. Approximately 25,000 weevils were used in the experiments. During 1957, LD-50 values varied among populations from different localities as follows: for toxaphene, from 12.5 to 61.8 μg. per gm. of boll weevil; for endrin, from 0.8 to 3.5 μg. per gm; for Guthion, from 0.9 to 2.3 μg. per gm. There was no evidence of acute resistance of the boll weevil from any of 5 localities to any insecticide tested. Mortality variations between times of year and between the 2 years were as great as among locality groups.

1960 - Parencia, C. R., Jr., and C. B. Cowan, Jr. Increased tolerance of the boll weevil and cotton fleahopper to some chlorinated hydrocarbon insecticides in central Texas in 1958. J. Econ. Ent. 53(1):52-56.

The boll weevil and cotton fleahopper (Psallus seriatus Reut.) showed increased tolerance to several of the chlorinated hydrocarbon insecticides in central Texas in 1958. Topical application studies on weevils reared from squares collected from one field in July indicated increased tolerance to

toxaphene and a high tolerance to dieldrin. In field experiments much better control was obtained with Sevin (1-naphthyl N-methyl carbamate) and such organic-phosphorus compound as Guthion (O,O-dimethyl S-(4-oxo-3H-1,2,3,-benzotriazine-3-methyl) phosphorodithioate) and malathion than with toxaphene and dieldrin. Dosages of toxaphene, dieldrin, and heptachlor 2 and 3 times those effective in previous years, failed to control the cotton fleahopper. Sevin, Guthion, malathion, toxaphene plus DDT, dieldrin plus DDT, and DDT alone were effective, but DDT has not been used against the cotton fleahopper for 10 years in this area.

1961 - Brazzel, J. R. Boll weevil resistance to insecticides in Texas in 1960. Tex. Agr. Expt. Sta. Prog. Rpt. 2171. Mar. 4.

A survey was conducted during 1960 to determine the status of insecticide resistance in the boll weevil in Texas. Boll weevils were collected from 20 areas of the State and treated with endrin and toxaphene. Results indicated 4 general areas with resistance levels sufficient to prevent economic control with these insecticides; these areas include parts of Hidalgo, Brazos, Maverick, Robertson, Burleson, and Bowie Counties. The central and north-central Texas areas appeared to be intermediate insofar as resistance was concerned. Weevils obtained from the remainder of the State were susceptible. There was evidence of a considerable reversion to susceptibility in the Mumford area, the first in which resistance was observed in 1956.

Since the results of this investigation are based on limited data, the classifications of areas as resistant or susceptible, in this report, should be considered only as an indication of the situation in any particular area.

NUTRITION

1958 - Leigh, T. F., and Theo Watson. Food and the fat content of the cotton boll weevil. Ark. Farm Res. p. 6. May-June.

The relationship between food eaten and fat content was studied. Newly emerged weevils from bolls contained 3.55% fat based on live weight, those newly emerged from squares - 1.34%, emerged from squares and fed on terminal growth 8 days - 2.21%, fed squares 8 days - 7.7%, and fed on bolls 8 days - 12.16% fat.

1958 - Vanderzant, Erma S., and T. B. Davich. Laboratory rearing of the boll weevil. A satisfactory larval diet and oviposition studies. J. Econ. Ent. 51(3):288-291.

Five generations of the boll weevil were reared aseptically from egg to adult on a semi-synthetic diet containing soybean protein, sucrose, corn oil, cholesterol, choline, vitamins, yeast extract, salts, cellulose alginate, agar, and water. The adults were allowed to feed and oviposit on squares. Average egg production was 3 eggs per female per day, with a maximum of 7 eggs. Cotton cotyledons also were found to promote oviposition of newly emerged adults. Weevils fed but did not oviposit on artificial diet unless cotton plant extracts were added. Oviposition also occurred on squares without bracts and squares that had been found, remolded, and coated with paraffin.

1959 - Brazzel, J. R., T. B. Davich, and Klaus Raven. Rearing boll weevils on an artificial diet. Tex. Agr. Expt. Sta. Misc. Pub. 353. Apr. 30.

A technique was developed for rearing large numbers of boll weevils from egg to adult in lots of 50 on an artificial diet under close confinement. The addition of a mixture of sorbic acid and methyl parahydroxybenzoate (methyl paraben) to the diet eliminated the necessity of aseptic procedures. About 70% of the eggs transferred to the diet developed into adults in 14 to 18 days. Weevils reared on this media were uniform in size and averaged about 12 milligrams in weight.

1959 - Earle, N. W., R. C. Gaines, and J. S. Roussel. A larval diet for the boll weevil containing an acetone powder of cotton squares. J. Econ. Ent. 52(4):710-712.

A larval diet for the boll weevil was developed using a protein source natural to the species--an acetone powder from squares, bolls, or leaves from the cotton

plant. The most successful diet contained acetone powder from squares in addition to agar, salts, sugar, vitamins, cholesterol, soybean protein, and water. The weevils reared on this diet are larger than those reared on diets using soybean protein or casein as the only source of protein. By adding 2 mold inhibitors, sorbic acid and methyl p-hydroxybenzoate, the need for the sterilization of the diet was eliminated. Successive generations of weevils can be maintained in the laboratory by allowing adults to feed and to oviposit in cotton squares. Eggs are then recovered from the squares and are placed in the larval diet. The weevils reach maturity in 2 to 3 weeks at 27° C.

1959 - Vanderzant, Erma S. Inositol: An indispensable dietary requirement for the boll weevil. J. Econ. Ent. 52(5):1018-1019.

Under aseptic conditions inositol was shown to be an indispensable nutrient for the boll weevil, and the amounts needed lie in the same range as those of the water-soluble vitamins.

1959 - Vanderzant, Erma S., C. D. Richardson, and T. B. Davich. Feeding and Oviposition by the boll weevil on artificial diets. J. Econ. Ent. 52(6):1138-1143.

Artificial diets are described for the adult boll weevil. Basal diets contained an enzymatic hydrolyzate of casein, glucose, corn oil, cholesterol, Wessons's salts, choline, ascorbic acid, B vitamins, water, and agar. Mixed pollen in amounts of 0.1 to 5 grams per 100 grams of the basal diet stimulated feeding and oviposition. Five generations of weevils were obtained on artificial diets without cotton-plant parts by rearing from egg to adult on a soybean protein diet and allowing the adults to feed and oviposit on a diet containing mixed pollen. Oviposition occurred when pollens from different families of plants were used. The only substance other than pollen that appreciably stimulated oviposition was wheat germ.

A basal diet containing homogenates of heated cotton plant parts, squares, flowers, germinated cottonseed, and young green seedlings also caused weevils to feed and oviposit. Tests with modifications of the basal diets are described. Substances that repelled the boll weevil when included in the basal diets were alfalfa meal, forage juice, distiller's dried solubles, yeast extract, and beef extract.

1960 - Solomon, J. D., and R. D. Hunter. Laboratory rearing of the cotton boll weevil. Ark. Farm Res. 9(3):5. May-June.

Procedures are described for rearing and supplying boll weevils for laboratory tests throughout the year. The composition of an artificial diet is given.

ALTERNATE-HOST PLANTS

1905 - Hunter, W. D. The control of the boll weevil, including results of recent investigations. U. S. D. A. Farmers' B. 216:32, 5 fig.

Observations were made on Mexican tree cotton. It was found that this species is not immune to weevil attack.

1914 - Coad, B. R. Feeding habits of the boll weevil on plants other than cotton. Agric. Res. J. 2(3):235-245.

Experiments were carried out by the author in connection with investigations on the biology of the boll weevil at Victoria, Tex., on the possibility of the boll weevil being able to breed in some of the native malvaceous plants. Various plants were tried, and the average longevity of the weevils on each was observed. On Sphaeraleae lindheimeri, the weevils fed readily, but deposited no eggs; the life of the weevil was short, and it is unlikely that the insect would ever become adapted to feeding on this plant. Weevils fed on Callirrhoe involucrata and C. pedata and lived a comparatively long time, but their chance of breeding was slight and only observed in rare instances.

Experiments made with A. grandis and A. grandis var. thurberiae on Hibiscus syriacus showed that it was quite possible for the insect to breed in the buds, and it seems probable that this would not be unusual. Louisiana and Texas boll weevils and the Arizona Thurberia weevil were all tested, the conduct of the 3 types in relation to feeding being practically the same. All showed the same preference for feeding first on the corolla and the stamens of the flower, followed by the buds, and then the fruit. The longevity of weevils fed on Hibiscus was little short of those fed on cotton. No weevils have been found breeding on plants other than cotton and Thurberia under field conditions, except a single individual on Hibiscus syriacus at Victoria, Tex., in June, 1913.

1914 - Howard, L. O. Report of the entomologist for the year ended 30 June, 1914. U. S. D. A. Ann. Rpt. Wash., D.C.

"Proof has been obtained that the cotton boll weevil has changed somewhat structurally since entering the United States, that it has become adapted to greater severities of climate, and is also now able to obtain subsistence and possibly to develop on certain plants related to cotton, among which are Hibiscus syriacus and Callirrhoe involucrata."

1915 - Coad, B. R. Recent studies of the Mexican cotton boll weevil. U. S. D. A. B. 231:34.

Present (1914) distribution extends from Costa Rica, north on the western slope of Mexico; north on the eastern slope of Mexico through eastern Texas, Louisiana, southern Arkansas, Mississippi, and Alabama, and southward through Yucatan, to central Cuba.

Food plants associated with the boll weevil are: Gossypium hirsutum, G. herbaceum, G. barbadense, G. brasiliense, Thurberia thespesoides, and Hibiscus syriacus.

Partial development has been noted on Callirrhoe involucrata, C. pedata and Sphaeralcea lindheimeri.

A detailed description of Anthonomus grandis Boh. and A. grandis thurberiae Pierce is included.

1916 - Worsham, E. L. Ga. State Bd. Ent. B. 44. March. Atlanta.

A. grandis is able to maintain itself on native Malvaceous and other plants, and this fact should be taken into account when considering methods of control.

1933 - Gaines, R. C. Progress report on the development of the boll weevil on plants other than cotton. J. Econ. Ent. 26(5):940-943.

To determine whether the elimination of cotton would result in the extermination of A. grandis, tests were carried out in Louisiana in 1932, in which hibernated weevils that had emerged from cotton squares placed in breeding cages or had been collected from the field were confined with 5 species of malvaceous plants. They fed freely on buds and blooms of Hibiscus syriacus and on the buds, blooms, and seed pods of H. militaris and less freely on blooms and seed pods of H. lasiocarpus. They fed sparingly on buds and seed pods of hollyhock (Althea rosea), and were not observed to feed on okra (H. esculentus). Some larvae hatched from eggs deposited externally on calyces or seed pods of H. militaris and H. lasiocarpus, but died, apparently without feeding. No eggs were deposited on hollyhock or okra. Three females developed from eggs laid normally in buds of H. syriacus.

1934 - Gaines, R. C. The development of the boll weevil on plants other than cotton. J. Econ. Ent. 27(4):745-748.

In further studies on Anthonomus grandis Boh. in Louisiana, 58 plants representing 4 species of Hibiscus were grown in an infested cotton field 10 to 12 feet apart with cotton plants growing between them and in adjoining rows. In buds collected from H. syriacus in August-September, 7 boll weevils developed, emerging after 10 to 16 days. This is apparently the first time that A. grandis has been found breeding in a plant other than cotton or Thurberia, under field conditions.

No weevils developed in H. militaris, H. lasiocarpus, or okra (H. esculentus), though adults were observed in the blooms of the first 2. In cages, they fed on blooms of all the species.

1935 - Bondy, F. F., and F. F. Rainwater. Boll weevil and miscellaneous cotton insect investigations. S. C. Agric. Expt. Sta. Ann. Rept. 48:100.

A study was made of boll weevil breeding on Thurberia althea and hollyhock. They were found to breed readily on Thurberia, and during 1935 3 larvae were found in althea buds; 1 lived to be an adult weevil. They fed on the hollyhock but did not deposit any eggs.

1952 - Szumkowski, W. El algodon de sabana. Cienfuegosia affinis (H.B.K.) Kochr. huesped del picudo del algodon Anthonomus grandis Boh. en Venezuela. Agron. Trop. 1(4):279-286. Maracay.

A. grandis, recorded in Venezuela for the first time on cotton in 1949, develops continuously throughout the year. Observations in 1950, to discover other food plants attacked, were made between February and July when cotton is not available. C. affinis was found to be another host.

1953 - Szumkowski, W. Nota preliminar sobre, Cienfuegosia heterophylla Garcke, planta hospedera de Alabama argillacea Hbn. y Anthonomus grandis Boh. en Venezuela. Agron. Trop. 3(2):121. Maracay.

Adults of A. grandis fed and laid eggs on Cienfuegosia heterophylla. Adults that fed on the buds and flowers survived for an average of 69 and a maximum of 134 days, and eggs were freely laid on the buds.

1956 - Lukefahr, M. A new host of the boll weevil. J. Econ. Ent. 49(6):877-878.

In July 1956, at Brownsville, Tex., the author noticed that several flower buds of Thespesia populnea (L.) Soland were turning yellow and falling off the tree. Upon examination he found that they were infested with what appeared to be boll weevil larvae. He also found four adult boll weevils on the foliage. All the flower buds and seed pods eventually became infested. Several of the infested buds were collected and 14 adult boll weevils emerged from them. All the adults were normal in size, which indicated an adequate food supply. Nine of them were placed in a cage containing potted cotton plants, and in a short time all the fruiting forms showed evidence of feeding or egg punctures.

Thespesia populnea belongs to the family Malvaceae and is commonly called portia trees or locally is referred to as a tulip tree.

1959 - Walker, J. K., Jr. Some observations on the development of the boll weevil on the wine cup, Callirrhoe involucrata (Nutt.) A. Gray. J. Econ. Ent. 52(4):755-756.

In the United States, 2 plants other than the cotton plant have been observed to serve as hosts for the boll weevil. These are Hibiscus syriacus L. and Thespesia populnea (L.) Soland, and both plants are members of the family Malvaceae. In Central Texas a very common malvaceous plant, the wine cup, Callirrhoe involucrata (Nutt.) A. Gray, blooms and matures during April and May. Eggs of the boll weevil were implanted into 4 wine cup buds. No adult weevils emerged from these buds although a later examination indicated that larval feeding had occurred in one bud.

In April 1957, boll weevils were removed from hibernation cages and transferred to small screen cages in the laboratory where they were provided with buds of the wine cup for food and oviposition. After a period of 2 weeks, examinations of the buds revealed the presence of boll weevil eggs. The insects also oviposited within the maturing fruit called capsules. In several instances, eggs were found deposited on the outside surface of the buds and capsules.

Boll weevil eggs were removed from cotton squares and implanted individually in wine cup buds. Each bud was partially enclosed with a thin layer of paraffin to prevent premature opening. Out of 40 buds in which eggs were implanted, 7 adult weevils emerged. Examination of other previously implanted buds indicated that a large percentage of the eggs hatched and the larvae lived for

several days. There was a high incidence of fungus contamination in buds in which eggs were placed. This may have accounted for the low yield of adults. Six capsules of the wine cup were implanted with eggs, but no adult weevils emerged. Observations of other capsules implanted with weevils eggs indicated that little or no larval development occurred.

In April 1958, newly emerged pairs of boll weevils were enclosed with wine cup buds as their only source of food. Copulation was first noted 6 days after confinement, and the weevils commenced to deposit eggs in the buds approximately 7 to 9 days after emergence. Four of the eggs deposited by these weevils were removed from buds, placed on moist filter paper and held at 80°F. All hatched within a 3-day period.

ATTRACTANTS AND REPELLANTS

1898 - Pino y Solis, Patricio. El Algodon en la Costa Grande (Estado de Guerrero). El Prog. de Mex. ano 5, p. 258-259. Feb. 8.

Expresses a belief that certain substances in the soil tend to protect the cotton from the boll weevil.

1924 - Anonymous. The control of the cotton weevil. Sci. 60(1554) Sup., p. 12. Oct. Garrison, N. Y.

Attempts are being made to discover which of the many complex substances in the cotton plant gives it its peculiar attraction for the cotton weevil. When this is known and the substance produced in sufficient quantities to be used as a bait for traps or mixed with poison, an important advance will have been made in controlling this pest.

1924 - Power, F. B., and V. K. Chesnut. Alkaline reaction of the cotton plant. Sci. 60(1557):405. Oct. 31. Garrison, N. Y.

The alkalinity of the dew of the cotton plant is believed to be attributable, at least in part, to the presence of ammonia and trimethylamine, which has been determined in it. They have also been obtained in very much larger amounts from the products of distillation of the cotton plant with steam. Both ammonia and trimethylamine are emanations from the plant and the latter possesses a particular attraction for the boll weevil.

1926 - McIndoo, N. E. Senses of the cotton boll weevil. An attempt to explain how plants attract insects by smell. Agr. Res. J. 33(12):1094-1141. Dec. 15.

A thorough investigation into the senses and sense organs of A. grandis made with the object of determining the means by which the cotton plant attracts the insect. The author studied the olfactory pores described by Hicks in 1857 in Hymenoptera and Coleoptera and decided that they serve as olfactory organs, and, having described the structure of the sense organs of both larvae and adults, he records experiments showing how plants attract insects by smell. He is very doubtful, however, whether it is possible for anyone to reproduce accurately the odor or odors that emanate from a plant merely by using the constituents derived from the plant by chemical means. Insects having a keener sense of smell than human beings should be able to distinguish the differences more readily. The antennae of boll weevils have 4 types of sense organs, including many innervated hairs, chiefly on the club, 3 or 4 olfactory pores at the base of each antenna and 2 so-called auditory organs in the second segment. Olfactory pores also occur on many parts of the body, in both adult and larva. The author believes the senses of smell and taste in insects to be inseparable. The olfactory sense seems to be the only one that can serve to attract the weevils to cotton plants from a distance and many experiments were conducted in the hope of finding a substance that would attract boll weevils as powerfully as cotton squares (flower buds) do. Saccharine, sugar, ice cream powder, a sweetened form of calcium arsenate, honey and 3 brands of molasses were tried, but none of them gave any indication of being of any practical use in the control of the weevils.

1928 - Morgan, A. C., and S. E. Crumb. Notes on the chemotropic responses of certain insects. J. Econ. Ent. 21(6):913-920.
Contains a statement that the boll weevil was not attracted to pyridine.

TESTING METHODS AND TECHNIQUES

1898 - Howard, L. O. Some miscellaneous results of the work of the Division of Entomology, Cotton Field Insects. U. S. D. A. Div. Ent. B. 18:85-88.
Record of insects caught in cotton field during a test of attraction of lights for the boll weevil. No weevils were caught, while 24,492 other specimens were taken.

1906 - Hinds, W. E. Laboratory methods in the cotton boll weevil investigations. U. S. D. A. Bur. Ent. B. 60:111-119. Sept. 22.
Descriptions are given of various devices used by the Bureau of Entomology in conducting investigations of the boll weevil.

1909 - Hood, C. E. Types of cages found useful in parasite work. J. Econ. Ent. 2(2): 121-124.
The author describes several types of cages used to rear boll weevils and parasites.

1926 - GeHauf, B. Breeding of boll weevils from infested cotton squares. J. Econ. Ent. 19(4):593-599.
The method that was found best for the production of large numbers of A. grandis for experimental purposes is described. Breeding and oviposition were carried out in the field under natural conditions and hatching in incubators. It was found that too much moisture caused the squares to rot before the weevil had reached its full growth.

1929 - Anonymous. Fla. Agr. Expt. Sta. Ann. Rpt. 1929:50.
An apparatus for determining the thermotropic reaction of insects was devised. Boll weevils showed definite orientation response to 26°F. at the chilled and 130°F. at the heated end of the apparatus, respectively. Geotropic reactions were also studied. Studies on resumption of egg laying by hibernated weevils indicated that fertile eggs could be laid without a preliminary 5-day square diet.
Isolated weevils laid eggs as many as 201 days after copulation. Females are consequently able to lay fertile eggs on emerging from hibernation.

1929 - Grossman, E. F. Thermotropism of the Mexican cotton boll weevil. J. Econ. Ent. 22(4):662-665.
A new apparatus for determining the thermotropic reaction of Anthonomus grandis (cotton boll weevil) is described. It consists of 16 copper bars, the ends of which form a plane so arranged that the weevils placed on them must be in contact with at least 2. The other ends of the bars are heated or chilled; they vary in length so that the temperature differs progressively. The average difference between 2 adjacent bars was 4°F.; the exact temperature of each bar can be ascertained by means of a thermocouple. Some differences were observed in the reaction of weevils ready for hibernation or removed from hibernation and those captured in the field in August. Variations in light conditions also had some effect. The average temperature at which the weevils definitely reacted was 26°F. at the chilled end of the plane and 130°F. at the heated end.

1931 - Folsom, J. W. A chemotropometer. J. Econ. Ent. 24(4):827-833.
A simple form of chemotropic apparatus and its method of operation are described. Records of chemotropic reactions of Anthonomus grandis Boh. obtained with this apparatus are given.

1933 - Gaines, J. C. Reliability of differences between data obtained in cotton insect investigations. J. Econ. Ent. 26(1):274-279.

A statistical comparison is made of methods used in taking cotton insect infestations and methods used in obtaining data on growth of cotton plants in experimental plots.

1933 - Gaines, J. C. Trap collections of insects in cotton 1932. Brooklyn Ent. Soc. B. 28(2):47-54.

In Texas in 1932 insect injury to cotton occurred throughout the whole season. Anthonomus grandis, Boh., which was numerous in early September, infested practically all the squares.

A list is given of 199 species, representing 61 families, of insects trapped in a cotton field during the period of mid-June to the end of August. The trap consisted of 2 pieces of screen wire tacked to frames which were nailed together to form a right angle and attached to 3 poles fixed in the ground in a triangle so that the bottom edges of the frames were about 3 feet above the ground. The wire was thickly coated at regular intervals with an adhesive.

1951 - Farrar, M. D., and John K. Reed. Methods for evaluation of cotton insecticides. J. Econ. Ent. 44(6):943-945.

By use of the vacuum duster technique, finished cotton dusts may be compared under laboratory conditions against the adult boll weevil. Adult boll weevils were reared from dropped cotton squares. On the third day they were caged onto cotton plants dusted with a commercial cotton dust mixture. Data obtained after 72 hours of exposure may be used in evaluation of the insecticidal property of each dust. Included are descriptions of apparatus and techniques.

1954 - Babers, Frank H., C. C. Roan, and R. L. Walker. Tagging boll weevils with radioactive cobalt. J. Econ. Ent. 47(5):928-929.

Describes methods of tagging boll weevils with Co^{60} and P^{32}. Adult weevils were tagged by emersion in aliquots of a working salt solution of the radioactive materials (activity - 6.6×10^5 C/M/ml). Wetting agents greatly increased the amount of radioactive solution retained by the weevil.

Tests were also made to introduce the radioactive materials into cotton plants. The stem of a small portion of growing cotton plant was immersed in a salt solution. Contrary to the rapid movement of P^{32}, the Co^{60} was slowly absorbed and it was several hours before appreciable radioactivity was present in the leaves. After 24 hours all portions of the plant were active, especially the cotton in the immature bolls. The acidity of the solution in which the stems were immersed had decreased from $8 \times 10^5 \pm 890$ C/M/ml. to $6 \times 10^5 \pm 775$ C/M/ml., showing that more of the cobalt had disappeared from the solution than was lost due to the water uptake of the plant.

1959 - Brazzel, J. R., B. G. Hightower, and T. L. Pate. A new method for the control of boll weevils. Tex. Agr. Expt. Sta. Prog. Rpt. 2110. Oct. 9.

A late season chemical and control program at College Station in 1959 showed promise in reducing the overwintered population of boll weevils. This reduction appears to be great enough to delay the start of boll weevil control programs the following year to effect substantial savings in insecticide costs. The program consists of chemical treatments just prior to and during the harvest period to prevent the weevil from going into diapause, the physiological condition in which they survive the winter. These insecticide treatments are followed by stalk destruction if harvest is completed before frost kills the cotton. Results obtained to date indicate this practice may be an effective eradication measure.

1959 - Clark, E. W., A. L. Williamson, and C. A. Richmond. A collecting technique for pink bollworms and other insects using a Berlese funnel with an improved heater. J. Econ. Ent. 52(5):1010-1012.

Through the use of heat, larvae of nondiapause pink bollworm, boll weevil, greater wax moth (Galleria mellonella L.), a phorid fly (Megaselia sp.), and

saprophagous flies were forced out of infested seed cotton, cottonseed, and green cotton bolls with little difficulty. A heater using a Nichrome wire grid which gave uniform heat was devised for large Berlese funnels, thus allowing large amounts of insect-infested material to be processed with high larval yield.

PLANT DISEASES

1917 - Worsham, E. L. Nineteenth annual report of the State entomologist for 1916. Ga. State Bd. Ent. B. 48, 36 p. Atlanta.

The control of the cotton boll weevil in Georgia is an entirely different problem from that faced by other states, because soil and climatic conditions are different. During 1916 the increase of the pest was rapid, although a systematic fight has been made in all counties where it occurred. A study of the possible insect transmission of cotton diseases led to the conclusion that while insects probably play but a small part in the dissemination of cotton anthracnose in a field, they may play a large part in carrying the disease from one field to another and from one plant to another when these are not in contact.

1934 - Taubenhaus, J. J., and L. D. Christenson. Insects as possible distributing agents of cotton wilt caused by *Fusarium vasinfectum*. (Abs.) Phytopathology 24(7):839-840.

In experiments in the United States, insects that had fed in screened cages on various parts of cotton plants infected with wilt (*Fusarium vasinfectum*) were surface-sterilized, together with some of their faecal pellets, and cultured on nutrient agar in petri dishes. Good growth of the fungus was recovered from the larvae of *Anthonomus grandis* Boh. When, however, insects fed on infested cotton were starved for several days until all the faecal matter had been eliminated, no fungus was obtained from sections of the alimentary canal. As the fungus recovered in these experiments was capable of infecting normal cotton plants, many insects that feed on cotton may aid the spread of the disease.

HISTORY OF THE BOLL WEEVIL

1843 - Boheman, C. H. Genera et species Curculionidum cum synononymia hujus familiae ed. C. J. Schonherr, 5(2):232-233.

The original description of *Anthonomus grandis*.

1871 - Suffrian, E. Verzeichniss den von Dr. Grundlach auf der Insel Cuba gesammelten Russelkafer. Archiv. f. Naturg. 37, Jahrg. 13, pt. 1, p. 130-131.

Contains the record of a specimen from Cardenas and one from San Cristobal, in Cuba.

1885 - Riley, C. V. Natural history of other species of the genus Anthonomus. Agr. Comn. Rpt. 1885:279. Wash.

Notice of the rearing of the boll weevil at the Department from dwarfed cotton bolls sent from northern Mexico by Dr. Edward Palmer. This is the first published record of the food plant and place of breeding of this species.

1891 - Dietz, W. G. Revision of the genera and species of Anthonomini inhabiting North America. Amer. Ent. Soc. Trans. 18:205.

Anthonomus grandis Boh. is here reported from Texas. (It was shown later, however, that this was an error.)

1894 - Howard, L. O. A new cotton insect in Texas. U. S. D. A. Div. Ent., Insect Life. 7:273.

The first authentic account of the occurrence of *Anthonomus grandis* Boh. in the United States from San Diego County, Tex., and statements regarding previous reports of occurrence.

1897 - Rios, J. R. Aparicion del "picudo" en la Laguna. El Progreso de Mexico, ano 4, p. 811-813.
A statement that the weevil had been found in a portion of the Laguna district at Viesca.

1898 - Sanderson, E. D. The Mexican cotton boll weevil. Tex. Farm & Ranch 17(47):3-4.
General account of origin, spread, and habits of the boll weevil.

1901 - Mally, F. W. The Mexican boll weevil. U. S. D. A. Farmers' B. 130, p. 29.
Includes a short paragraph on migration habits.

1902 - Hudson, E. H. The Mexican boll weevil (Anthonomus grandis). Farm & Ranch 21:13.
A brief description and history of the insect.

1902 - Hunter, W. D. (History and distribution of the weevil.) Boll weevil convention. Farm & Ranch 21:12. Dec. 27.
A brief history of the boll weevil, with statement of its distribution at that time. The impossibility of extermination is brought out.

1902 - Hunter, W. D. The probability of the occurrence of the Mexican cotton boll weevil in Brazil. U. S. D. A. Bur. Ent. B. 38:105-106.
Remarks regarding probable occurrence of Anthonomus grandis in Brazil.

1903 - De La Barreda, L. El picudo en San Pedro de la Colonia. Comn. Parasit. Agr. B. 2(2):45-58. Mex.
Report on investigations of the Comision into the spread of the boll weevil by means of the movement of cotton seed. Methods of treating seed to kill weevils are discussed; also recommendations that the Mexican Government pass laws controlling the importation of cotton seed from the United States.

1904 - Herrera, A. L. Cuestionario relativo a las plagas de la agricultura. Comn. Parasit. Agr. B. 2:278, 279, 280, 303. Mex.
Notes regarding occurrence of weevils in certain localities in Mexico and injury due to them.

1904 - Hunter, W. D. Information Concerning the Mexican Cotton-Boll Weevil. U. S. D. A. Farmers' B. 189:31, fig. 8.
In this bulletin, a historical account is presented of the introduction and distribution of this pest in the United States, with a special account of the territory infested at present, the amount of damage, and a plan of the investigations of the Division of Entomology. Notes are given on the life history and habits of the insects and on local restrictions regarding the shipment of infested cotton seed in Alabama, Georgia, North Carolina, Mississippi, and Louisiana. The author states that certain dealers have raised the price of cotton seed alleged to be of northern origin far beyond the actual value of the seed, and in some cases when the seed concerned was not of northern origin.

1904 - Hunter, W. D. Present status of the cotton boll weevil in the U.S. U. S. D. A. Ybk. 1904:191-204, 2 pl., 1 fig.
An account is given of the territory affected by this pest, the amount of damage done, and the investigations by the USDA concerning the boll weevil, together with notes on problems still to be solved.

1904 - North, S. N. D. Quantity of cotton ginned in the United States (crops of 1899 to 1903, inclusive). U. S. Dept. Com. & Labor., Bur. Census B. 10(9):15-17.
Contains a brief history of the spread of the weevil in Texas.

1904 - Schwarz, E. A. The cotton boll weevil in Cuba. Ent. Soc. of Wash. Proc. 1(1):13-17.
A report of the writer's findings on studies to find the original food plants of the boll weevil.

1904 - Williams, C. A. What Government experts are doing to destroy the boll weevil. World Today 7(1904) 4:1307-1313, 11 fig.
The author briefly discusses the economic importance of cotton and the great injury which this industry has suffered from the ravages of the boll weevil. Attention is called to work outlined for the control of the boll weevil, and brief hints are given as to future work.

1905 - Anonymous. The boll weevil in Texas. U.S. Dept. Com. & Labor, Bur. Census. B. 10:15-17, fig. 1.
The history of this pest is briefly outlined with notes on its present distribution in Texas and the amount of damage caused by it. An account is given of methods used to eradicate the weevil.

1905 - Cook, M. T. Notes on Cuban insects. U. S. D. A. Bur. Ent. B. 52:29.
Contains the statement: "The boll weevil is very abundant."

1905 - Hunter, W. D., and W. E. Hinds. The Mexican Cotton-Boll Weevil. U. S. D. A. Div. Ent. B. 45:116, 1904. Revision and amplification: U. S. D. A. Bur. Ent., B. 52.
The most comprehensive account of the boll weevil published up to this date.

1906 - Champion, G. C. Biologia Centrali-Americana. Coleopt. 4(4):722. Apr.
Boll weevil recorded from San Jose, Costa Rica.

1906 - Hunter, W. D. Areas infested by the cotton boll weevil, October 10, 1906. Farm & Ranch 25:16. Nov. 24.
A statement of the distribution of the boll weevil in the United States, with remarks on the ability of the pest to adapt itself to various climatic and other conditions.

1906 - Hunter, W. D., and W. E. Hinds. The Mexican cotton boll weevil. U. S. D. A. Bur. Ent. B. 51:181, 23 pl., 8 fig.
This is essentially a revised and enlarged edition of Bulletin 45. Part of this information contained in the bulletin is also contained in Farmers' B. 216 and Bur. of Entom. C. 56.
The present account is a monograph of the boll weevil and contains a discussion of the insect from every standpoint. The investigations of 1904 served to confirm previous studies. The recommendations regarding cultural methods are repeated. A bibliography of the subject is appended to the bulletin.

1908 - Hunter, W. D. The cotton boll weevil in Oklahoma. Okla. State Bd. Agr. 1st Bien. Rpt. to the legislature of the State, for the years 1907-1908, pt. 5:36-42.
Brief history of the weevil in the United States and summary of its life history and habits. The distribution of the cotton boll weevil in Oklahoma is outlined and a statement is made regarding prospects for injury by the pest.

1908 - Newell, Wilmon, and A. H. Rosenfeld. A brief summary of the more important injurious insects of Louisiana. J. Econ. Ent. 1:151.
Note regarding comparative area of boll weevil infestation in Louisiana. Fifteen thousand square miles are heavily infested; 14,000 square miles have comparatively slight infestation.

1909 - Sherman, F., Jr. Erroneous reports of the cotton boll weevil--Its present status. N. C. Dept. Agr. Ent. C. 21:4.

Reports to the effect that the cotton boll weevil has been found in North Carolina are declared to be without foundation. At present this insect occurs in eastern Texas, Oklahoma, Arkansas, Louisiana, and Mississippi.

1910 - Harned, R. W. Boll weevil in Mississippi, 1910. Miss. Sta. B. 139, 43 p., 28 fig.

Following a general account of the boll weevil, the author discusses its occurrence in Mississippi, at length. During 1909, the boll weevil spread over a much larger portion of the State than during the previous year. Pike, Lincoln, Copiah, Hinds, Warren, and Issaquena counties, which were partially infested in 1908, are now entirely within the infested area, as are also Lawrence, Jefferson, Davis, Marion, Lamar, Pearl River, Hancock, and Harrison counties and other counties partially infested.

Accounts of methods of control and descriptions of the weevils mistaken for the boll weevil follow.

1910 - Hinds, W. E. The boll weevil advance in Alabama. Ala. Col. Sta. C. 5:6.

It was stated that the boll weevil was found for the first time in Alabama, September 3, 1910, on the western edge of Mobile County. Its advance was so rapid that by the middle of September the line of infestation included about 3/4 of the county and 10 days later weevils were found in the southern part of Choctaw County. The author considered it probable that by the time of the first frost, they would have reached as far north as the southern part of Pickens County and as far east as Covington County.

The biology of the weevil is briefly summarized and attention called to importance of the immediate adoption and practice of control measures.

1910 - Hunter, W. D. The status of the boll weevil in 1909. U. S. D. A. Bur. Ent. C. 22, 12 p.

A concise statement of boll weevil conditions in 1909. An estimate is made of the percentage of the cotton area of each State which was infested at the end of the season in 1909. A discussion is given of the factors which tended to reduce damage during 1909 and of the dispersion during that year. Under "History in Texas" appears a discussion of the cotton production in different sections of Texas. This nicely illustrates the effect the weevil had had on the cotton production of the State.

1911 - Nicholson, J. F. Report of the Department of Botany and Entomology. Okla. Sta. Rpt. 1908:19-42 (1908-09).

"The boll weevil appeared in sufficient numbers to become injurious."

1912 - Hunter, W. D. The movement of the Mexican cotton boll weevil in 1911. U. S. D. A. Bur. Ent. C. 146, 4 p. Feb. 12.

During the season of 1911 the boll weevil was greatly reduced in numbers throughout its entire range. This resulted from a combination of climatic influences extending over a period of about 3 years. So unfavorable were the conditions that the insect was exterminated in an area covering about 23,000 square miles in the northwest portion of Texas and the western portion of Oklahoma. Undoubtedly these conditions had an important bearing on the production of the large crop in 1911.

1912 - Hunter, W. D., and W. D. Pierce. The Mexican boll weevil: A summary of the investigations of this insect up to December 31, 1911. Sen. Doc. 305, 188 pages.

A very comprehensive documentation of work and observations on the boll weevil. The origin and history of the weevil are discussed. Comments are made on its present distribution, direct and indirect losses, and future prospects on living with this insect. Observations on its natural and artificial dissemination are recorded.

1913 - Anonymous. Fla. Agr. Expt. Sta. Ann. Rpt. for fiscal yr. ending June 30, 1912:1-11. Mar. 13.

Boll weevils reached Florida in the fall of 1911. Specimens were sent in from Escambia County. U. S. Bureau of Entomology reported it in Santa Rosa County.

1913 - Cook, O. F. A wild host plant of the boll weevil in Arizona. Science, n. s. 27(946):259-261.

This article contains the first record of the occurrence of a weevil attacking Thurberia thespesoides in Arizona.

1913 - Hunter, W. D., and W. D. Pierce. The movement of the cotton boll weevil in 1912. U. S. D. A. Bur. Ent. C. 167:1-3, 1 map. Jan. 28.

Notwithstanding a set-back, due to the very unusual climatic conditions of the winter of 1911-1912, the cotton boll weevil gained 7,300 square miles, the total area infested being 278,800 square miles, as follows: 149,700 sq. miles in Texas, (139,300 in 1911); 40,800 sq. miles in Louisiana (stationary); 2,100 sq. miles in Oklahoma (6,300 sq. miles in 1911); 25,000 sq. miles in Arkansas (33,900 in 1911); 3,600 sq. miles in Florida (1,400 in 1911).

1913 - Pierce, W. D. The occurrence of the cotton boll weevil in Arizona. J. Agr. Res. 1(2):89-98.

In February 1913, an insect resembling the cotton boll weevil was found breeding in the bolls of a shrub known as Thurberia thespesoides in Ventura Canyon, Arizona. A close examination of the material disclosed many minor points of difference from the usual form of the cotton boll weevil. In addition to these differences of structure, certain differences of habit were noted: It was found, however, that A. grandis would feed upon Thurberia, while the Arizona species would equally feed on cotton; and it was possible to obtain crosses of the two forms. It was, therefore, decided to regard the two as being merely different varieties of the same species. For the Arizona variety the name, A. grandis thurberia, Var. N., was proposed. A systematic description and an account of the life-history are given.

1913 - Townsend, C. H. T. On the history of cottons and cotton weevils. Sci. 37:638-639. Apr. 25.

Referring to his article on the Peruvian square weevil in J. Econ. Ent. for April 1911, the author believes that he has now collected sufficient palaentological evidence for the deduction that "A. vestitus has probably attacked cotton in humid northwestern South America for upwards of a million years, if not longer. It is, therefore, extremely probable that this species is not confined to Peru and Ecuador." One of the periodic separations between North and South America explains the fact that A. vestitus does not occur in North America and that A. grandis was not dispersed as far as South America. Both the weevils have originally developed on cotton, having no other foodplant.

1913 - Watson, J.R. Insect pests of the year. U. Fla. Agr. Exp. Sta. Rpt. for 1912:62-63. Mar.

"The boll weevil reached Florida in the autumn of 1911. Specimens were received from Escambia county and it was reported from Santa Rosa County."

1914 - Bailey, V. The wild cotton plant (Thurberia thespesoides) in Arizona. Torrey Bot. Club. B. 12(5):301-306, 2 fig. May. New York.

A. grandis has been found abundantly on wild cotton in the canyons of Santa Catalina Recon, and Santa Rita mountains of S. Arizona, but not north of the Gila River.

1914 - Wolcott, G. N. The cotton boll weevil in Cuba. Ent. Soc. of Wash. Proc. 16(3):120-122. Sept. Wash.

A chronological record of A. grandis in Cuba states that the cotton boll weevil was first recorded there in 1871. From 1900 cotton cultivation spread

widely, until a plague of boll weevils entirely destroyed the crop, and no cotton was planted except for a few small plots at the Estacion Agronomica, Santiago de las Vegas. Wild treecotton plants remained to furnish the boll weevil with a food supply, but later the larger cotton trees in Western Cuba were destroyed by a series of hurricanes. From 1908 to May 1912, no boll weevils have been found on the cotton at Estacion Agronomica. At Artemisa, cotton entirely free from the boll weevil has been cultivated from 1909 to 1912, the grower attributing his success largely to the fact that the cotton was planted towards the end of the rainy season in October or November, and harvested in the spring, before the rains began. No boll weevils have been discovered to date, except near Cienfuegos in Central Chapana, where in February 1914, 3 cotton plants were found to be attacked. Cotton is not grown commercially there, and no other plants in the neighborhood seemed to be injured. Eight adult boll weevils were collected, 6 of which were destroyed a few days later by the ant Solenopsis geminata.

In March 1914, the author visited Kingston, Jamaica, and reported that no boll weevils were to be found on any of the varieties of cotton grown there.

1914 - Worsham, E. L. The Mexican cotton boll weevil. Ga. State Bd. Ent. B. 39, 24 p., 1 fig., 7 pl. Feb. Atlanta.

The cotton boll weevil reached a point about 6 miles from Georgia in the autumn of 1913. The average rate of extension of the pest is about 65 miles a year, and it is estimated that in 1916 or 1917, the weevil will become generally destructive in the State.

1916 - Anonymous. Pests and diseases of cotton and their control. Agr. News 15(368):182-183. June 3. Barbados.

"Importations from the United States might introduce the Mexican cotton boll weevil into the West Indian Islands, though its importance there might not be so great as in the Southern States."

1916 - Riggs, W. M. Report of the South Carolina Boll Weevil Commission. S. C. Agr. Expt. Sta. B. 20, 23 p. Nov. 23, 1916. Clemson.

Reviews the conditions as regards A. grandis in other States and discusses the inevitable results of the probable introduction of this weevil into South Carolina. Intelligent cooperation amongst the community is urged in order to make all possible provision for meeting the first of weevil infestation and to prevent disaster due to the initial panic following the first crop failure.

The general aspects of the boll weevil question dealt with include the life history of the pest, the record of its spread in the United States, climatic and other conditions of South Carolina as compared with other States, and the cultural methods that are the only known means of control in infested fields.

The effects of boll weevil infestation are discussed, with its bearing upon cotton production, oil mills, and ginneries, as well as upon labor and land values, together with the changes in agricultural methods which the presence of the weevil entails. The importance of hastening the growth of plants so as to insure a large crop of bolls by the middle of July is emphasized, and simple directions are given for following scientific methods of cultivation which will represent a good investment while no weevils are present and will check their numbers when they do become introduced. The report closes with general observations, suggestions, and recommendations to be followed in preparation for boll weevil conditions.

1916 - Worsham, E. L. Ga. State Bd. Ent. B. 44, 22 p., 4 fig., 7 pl. Mar. Atlanta.

A. grandis was first recorded in Georgia on August 25, 1915, when a specimen was taken at Thomasville. By Nov. 16, 1915, records were made in about 40 counties in most of which the insect was abundant. The introduction into Georgia was due to the high winds which occurred for a few days before its appearance. The area of new territory covered by the weevil in 1915 was estimated at 86,000 square miles.

1917 - Anonymous. An illustration of the importance of quarantine against injurious insects. J. Econ. Ent. 10(2):298.

The cotton belt of Brazil, after thorough examination in 1914, was pronounced to be free of the boll weevil. The pink bollworm was found to be general throughout the cotton growing area in 1916.

1917 - Hunter, W. D. The boll weevil problem, with special reference to means of reducing damage. U. S. D. A. Farmers' B. 848, 40 p.

Contains a general account of the boll weevil problem, the history of the insect in the United States, the damage it has done in different regions and the reason for local variations in damage, the indications for the future, habits of the weevil relative to control procedures and means of reducing injury.

1918 - Anonymous. El algodonero in Colombia. Revista Agricola 4(5, 8 & 9):263-270, 503-512, & 551-567, 6 fig. May, Aug. & Sept. Bogota.

In the course of this paper on cotton cultivation in Colombia, some account is given of insect pests of this plant, including Anthonomus grandis, which has not yet appeared in Colombia.

1918 - Ballou, H. A. Spread of the Mexican cotton boll weevil in the U. S. Agr. News 17(428):298. Barbados.

Discussing an account published by the USDA on the present situation with regard to the cotton boll weevil and its spread during recent years, the author remarks that it is of great interest to cotton growers in the West Indies to note that for a period of 25 years the Mexican boll weevil has spread steadily through the cotton belt of the southern States at an average rate of more than 15,000 square miles each year, that the Sea Island cotton districts of Georgia and Florida are invaded, and that the pest has reached South Carolina and at the end of 1917 threatened the Sea Island cotton district of that State.

The output of Sea Island cotton from those States is bound to suffer a reduction and it is pointed out that in view of the high cost of production, growers of this class of cotton are likely to turn their attention to the substitution of a more profitable crop. In that case the West Indian cotton growers will be in an increasingly strong position, and it becomes more than ever a matter of national importance to protect the cotton industry throughout the Islands.

It is pointed out that A. grandis has within a period of 25 years spread over an area of nearly 500,000 square miles and in a few years more will infest the whole of the cotton belt (some 600,000 square miles). This steady spread has been in the face of strenuous exertions to check its increase.

1918 - Isley, D. Entomology. Ark. Agr. Exp. Sta. B. 158:45-49. Dec. Fayetteville.

The cotton boll weevil was present in great numbers.

1919 - Sherman, F. Report of the Division of Entomology. N. C. Agr. Exp. Sta. 42d Ann. Rpt., 1918-19:54-58. Raleigh.

"The spread of the cotton boll weevil (A. grandis) into North Carolina is recorded."

1920 - Hurd, W. E. Influence of the wind on the movements of insects. Mo. Weather Rev. 48(2):94-98. Wash.

"The importance of wind to migratory swarms of locusts is well known. Two of the most sharply defined extensions of the Mexican cotton boll weevil in Texas occurred in 1915 and 1916, and were largely due to the sweeping winds experienced in those years."

1921 - Barre, H. W. Insect Pests. S. C. Exp. Sta. 34th Ann. Rpt., year ended June 30, 1921:29-36, 2 fig. Dec. Clemson.

"The cotton-boll weevil. . .now occurs throughout the State and if cotton is to continue to be grown, it must be done in accordance with the improved practices developed by the more southern States to meet the same conditions."

1921 - Coad, B. R., and R. W. Moreland. Dispersion of the boll weevil in 1920. U. S. D. A. C. 163, 2 p. Jan.

During 1920 the movement of the boll weevil was retarded in the eastern portion of the cotton belt, but a large portion of territory has been reinfested in Oklahoma and Texas. Altogether 42,621 square miles of new territory was invaded in 1920, and only 752 square miles were freed, this occurring in Tennessee. Only about 72,000 sq. miles of cotton producing territory remained uninfested. The extent of infestation in each State is briefly dealt with. Considering the cotton producing States as a whole, an average of only 16.2% of the total cotton crop is produced in uninfested territory.

1921 - McDonald, R. E., and M. C. Tanquary. Report on the pink boll worm situation in Mexico. Tex. Dept. Agr. Mo. News B. 3(5):6-7. Feb. and Mar. Austin.

This report was made as the result of a visit, from November 26 to December 1, 1920, to the Laguna region of Mexico. Certain limited areas in Texas and Louisiana are now infested with Platyedra gossypiella, and this infestation came from Mexico.

Other cotton pests include the cotton boll weevil which appears to have been present for 25 years or more, but does not do much injury, probably owing to the arid climate.

1922 - Coad, B. R., E. S. Tucker, W. B. Williams, F. F. Bondy, and R. C. Gaines. Dispersion of the boll weevil in 1921. U. S. D. A. C. 210.

The cotton boll weevil has now reached the limit of cotton cultivation in the United States, except in Western Texas, Southwestern Oklahoma, Northeastern North Carolina, and Virginia. The situation in the various States is briefly outlined. In all 66,662 square miles of new territory were invaded by the weevil in 1921, making a total of 600,771 squares miles. About 105,000 square miles of cotton territory are still uninfested. A map shows the spread of the weevil from 1892 to 1921. Tables record the movement of the pest in 1921 by States and the proportion of the cotton crops of each State produced in uninfested land. Only 5.4% of the crop from the cotton belt originated from uninfested land.

1923 - Anonymous. Entomological notes. U. S. D. A. Ybk, 1922: p. 31.

The cotton boll weevil is now found in all the cotton growing States. Calcium arsenate dust properly applied is very beneficial. It is not possible as yet, however, to reduce the cost of this treatment to a point where it will be profitable on land producing less than half a bale of cotton to the acre. It is hoped that aeroplanes may prove to be of practical use in distributing this poison. Losses caused by the boll weevil for the years 1909-1921 are recorded on p. 714.

1923 - Anonymous. Reported occurrence of the boll weevil in the Northern Territory. Queensland Agr. J. 20(2):101, Aug. Brisbane.

The recent report of boll weevil from cotton fields in the Northern Territory is erroneous and apparently referred to Platyedra gossypiella (pink bollworm). According to a report of H. Tryon, the latter definitely exists in the Northern Territory, in view of which he suggests the isolation of this region with respect to cotton from the remainder of Australia.

1923 - Bondy, F. F., R. C. Gaines, W. B. Williams, and M. T. Young. Dispersion of the boll weevil in 1922. U. S. D. A. C. 266, 6 p., 1 fig., 2 t., Wash.

In 1922, 22,386 square miles of new territory were invaded by the cotton boll weevil, the greatest increase in infestation being in North Carolina with 16,363 square miles. In Texas and Oklahoma the infested area decreased by 8,944 square miles, thus leaving a net increase of 13,442 square miles for the cotton belt. Only 4% of the cotton crop is now produced outside weevil-infested territory.

1923 - Kelly, E. G. Note on the cotton boll weevil in Kansas. J. Econ. Ent. 16(6):552.

A number of adults and larvae of the cotton boll weevil were found on cotton in southern Kansas (Montgomery County) in Oct. 1923.

1924 - Anonymous. The insect pest survey bulletin. U. S. D. A. IV, No. 1, 22 p., Multigraph, Apr. 1. Wash.

"Severe weather in the Southern States seems to have killed many hibernating boll weevils."

1924 - Schoene, W. J. Fourteenth report of the State entomologist and plant pathologist. Va. State Crop Pest Comn. Q. B. 4:5-27, 6 fig. Jan. Blacksburg.

During the period from October 1921 to September 1923, covered by this report, 2 very important insect pests have appeared in Virginia, namely, the cotton boll weevil and Epilachna corrupta (Mexican bean weevil). Cotton is a relatively unimportant crop in Virginia; the soil is suitable only in a few localities, and cotton is grown only in rotation with other crops. The low winter temperatures in Virginia may also destroy many of the weevils. An estimate is tabulated, of the loss anticipated in 1924 on account of the weevils and general recommendations for reducing infestation are given.

1925 - Jordan, H. Toll of the cotton boll weevil. N. Y. Commercial, reprint, 8 p. July 7. New York.

The situation resulting from the gradual extension of the cotton boll weevil over the cotton crop from southwest Texas to Virginia during the past 30 years is reviewed, an analysis of the position in each State being given. An examination of the facts shows that no State, after infestation, has been able to regain its former yield per acre (with the possible exception of Oklahoma in 1924).

Most of the States would be obliged to double their acreage in order to obtain the same productive yield as under pre-weevil conditions. Experience has shown that there is no profit to the grower unless at least one bale of cotton per acre can be produced, and during the years 1920-1924, the cotton States showed an average yield of 1 bale per 3.2 acres.

It is suggested that the future production of cotton must be undertaken on a restricted acreage and a highly intensive system of cultivation. The average farmer cannot successfully cultivate and handle more than 5 to 7 acres under cotton per plough under boll weevil conditions. Demonstrations of cotton growing have proved of incalculable value and well worth the outlay entailed.

1926 - Schoene, W. J. Fifteenth report of the State entomologist and plant pathologist 1924-25. Va. State Crop Pest Comn. Q. B. 7(4):5-31, 3 fig. Jan. Blacksburg.

"Anthonomus grandis Boh. has now spread over the entire cotton growing territory, and serious losses from it may be expected in 1926 and 1927."

1929 - Newell, W. Comments on entomology in the South during the past twenty-five years. J. Econ. Ent. 22(5):732-735.

Contains brief history of the spread of the boll weevil.

1931 - Coad, B. R. Insects captured by airplane are found at surprising heights. U. S. D. A. Ybk, 1931:320-323.

The boll weevil has been found at as high as 1,000 ft. elevation.

1931 - Howard, L. O. The insect menace. 347 p. The Century Co. New York.

To instance the great progress that has taken place during the last half century in the United States in appreciation of the importance of taking adequate measures to combat dangerous pests, a comparison is drawn between the amount of funds and work expended on the Mexican boll weevil from the commencement of outbreaks in 1894.

1934 - Sanborn, C. E. History and control of the boll weevil in Oklahoma. Okla. Agr. Expt. Sta. B. 222:4-9. June.

Traces introduction and history of weevil in Oklahoma.

1937 - Audant, A., and A. Occenad. The Mexican cotton boll weevil, Anthonomus Grandis Boheman, in Haiti. Puerto Rico U. J. Agr. 21(1):69-76, 1 map. Jan. Rio Piedras.

Anthonomus grandis Boh. which was formerly confined to the southwestern United States, the cotton growing regions of the Pacific, and Gulf coasts of Mexico,

and a few localities in Central America, was accidentally introduced into Haiti about 1932 and had become a major pest of perennial cotton by 1935. Before its introduction, the annual export of cotton from Jacmal over a period of 9 years averaged about 1,400,000 lbs., but since 1932 the amount has fallen steadily and was only about 256,000 lbs. in 1935-36. A similar decrease in production has resulted in other infested districts. Owing to strict quarantine regulations, infestations has not yet spread to all the cotton growing districts, though it is impossible to eradicate the weevil or prevent its spreading in the direction of the prevailing winds. Perennial cotton produces fresh green leaves, on which the adult weevils feed, for almost the entire year, and so completely shares the ground between the rows that the immature stages in fallen bolls and squares are not killed by the heat of the sun.

The production of squares is largely confined to 2 months, but sufficient numbers are produced outside this period to allow the weevil a much longer phase of reproduction than do strains of American upland cotton specially selected for a short season. The Haitian strains of perennial cotton are, however, very resistant to the pink bollworm (Platyedra gossypiella, Saund.). Infestations of this pest do not normally exceed 1-2 percent, even at the very end of the picking season. It has been suggested that they should be replaced by an annual short season type, but it is possible that A. grandis may eliminate the strains susceptible to its attack, just as P. gossypiella has eliminated imported varieties.

1940 - Campbell, Roy E. Studies of aerial activities of insects. J. Econ. Ent. 33(4):710.

Insects caught at high altitudes on traps attached to aeroplanes in Louisiana and Mexico included boll weevils at 2,000 feet, spotted cucumber beetles (Diabrotica duodecempunctata F.) at 3,000 feet, and leafhoppers at 13,000 feet.

1940 - Ceasar, L. Fifty years of entomological progress, part II, 1899 to 1909. J. Econ. Ent. 33(1):17-18.

The cotton boll weevil, by 1899, had become so abundant and caused so great damage--about $25,000,000 a year--to cotton fields that it was clearly seen that, if no effective control could be devised, the growing of cotton would soon have to be abandoned. This would have meant bankruptcy and indescribable suffering to the South, for cotton was their great crop and the source of by far the greater part of their income.

Under these conditions, the Bureau of Entomology, in 1901, began one of the best planned and most extensive investigations of all time and carried it out just as thoroughly as it had been planned. Before the end of the decade so much progress had been made that Dr. W. D. Hunter and Dr. W. E. Hinds were able to demonstrate on a large scale to the growers that by adopting certain cultural practices, especially planting early maturing varieites and harvesting the same early in the fall and destroying all stalks and remnants, the South could continue indefinitely to grow cotton at a profit in spite of the weevil. This discovery gave hope and courage to the farmers and at the same time gradually brought about much better and more diversified methods of farming in the affected areas.

The thoroughness of the investigation also helped greatly in the way of progress by serving as a great example and inspiration to other entomologists to plan and carry out their investigations with greater care, and especially to take into account more fully than before climatic and all other environmental factors; for it was largely by close attention to these that it had been possible to work out the control.

1940 - Marlatt, C. L. Fifty years of entomological progress, Part I, 1889 to 1939 Cotton Boll Weevil. J. Econ. Ent. 33(1):13-14.

The entry into Texas of the Mexican cotton boll weevil was discovered in 1894. That this insect occurred in and was very destructive to cotton in Mexico was brought to Dr. C. V. Riley's attention some 9 years earlier (1885) by Dr. Palmer, a biological explorer, who had been working for some time in Mexico. Dr. Palmer reported that the depredations of the insect had led to the abandonment of cotton at various points in that country, and particularly in the

neighborhood of Monclova, opposite to, and not far from Laredo, Tex. Dr. Riley published this information in his annual report for that year, but did not mention, and probably had no thought of, a quarantine to prevent the entry of this new pest into the United States. In fact at that time, quarantine consciousness seemed not to have developed in the United States outside of California.

This insect made its entry into Texas at Maramoros, near the mouth of the Rio Grande and, when reported, had already advanced along the Gulf and northward. By the end of the decade it had reached San Antonio, and covered a fan-shaped area southward to the Gulf. Here again, from our present outlook, it seems extraordinary that there was no immediate discussion of the possibility of eradication under state and federal action, which certainly now would be the first thought. Instead, a letter was sent by the Assistant Secretary of Agriculture to the Governor of Texas, urging importance of a state quarantine to prevent the spread of the weevil in Texas and the enforcement of remedial work. No action followed.

During this decade the division was given special funds to aid in boll weevil control, and little more could be done than to determine the spread of the insect, work out its biology, and make a preliminary study of means of control. The first Federal appropriation ($250,000) with respect to this insect was in 1903--of which, however, only $20,000 was assigned to the Division of Entomology--the Bureau of Plant Industry, having a program already worked out, received the bulk of the fund.

1945 - Loftin, U. C. Living with the boll weevil for fifty years. Smithsonian Rpt. for 1945:273-292, 10 pl.

A review of the history of the boll weevil, its impact on the economy of the South, and cultural and chemical control methods developed for its control. Recent progress in developing many new materials for insect control has stimulated renewed research for a better insecticide then calcium arsenate for the boll weevil. DDT is not the answer for the boll weevil, but if further experimentation confirms the preliminary results, some of the new synthetic insecticides, such as benzene hexachloride, may be the beginning of a new era in boll weevil control.

1950 - Feujves, P. Einige probleme der angewandten entomologie in Venezuela. Mitt. Schwiez ent. Ges. 23 (2):135-154. Berne.

Cotton heavily infested by A. grandis which was recorded on it in Venezuela in 1949 for the first time in South America.

1952 - Gaines, R. C. The boll weevil. U. S. D. A. Ybk 1952:501-504.

A brief review of the history of the boll weevil and various control procedures used during the past 60 years.

1953 - Berry, P. A., and L. Abrego. Insects and diseases affecting some crops in El Salvador. FAO Plant Prot. B. 1(10):151-153. Rome.

Most serious pest of cotton in El Salvador is A. grandis, which was shown to feed and breed throughout the year. No alternative foodplants are known.

1957 - Robertson, O. T. Occurrence of the boll weevil in the Big Bend of Texas. J. Econ. Ent. 50(1):102.

The boll weevil was seldom found prior to 1953 in the Big Bend area of Texas. The nearest infestation where it caused damage was at Delicias, Chihuahua, Mex., about 100 miles away. It is seldom a pest in the High Plains or west of the Pecos River in Texas, and has never caused commercial damage west of the Big Bend in the United States. An outbreak observed in 1953-55 is significant since it occurred more than 200 miles west of cotton producing areas in Texas where damage usually occurs.

1960 - Miner, Floyd D. Cotton insects in Nicaragua. J. Econ. Ent. 53(2):291-296.

The cotton insect problem in Nicaragua is in many respects similar to that in the United States. The most serious pests are the boll weevil and Sacadodes

pyralis Dyar, a Phalaenid which bores into bolls. The boll weevil passes the dry season between crops in old cotton fields. Reproduction apparently ceases during this time. Early infestations in young cotton were heaviest in fields planted before the usual date. Peak infestations occurred when the crop was approaching maturity. The life cycle is similar to that in the United States. Sacadodes also was generally a late-season pest, and was particularly serious in late-planted fields. Infestations of both insects were reduced by means of insecticides, but increases in yield were small.

SURVEYS

1908 - Hunter, W. D. Boll weevil scarcer. Tex. Stockman & Farmer 26(27):7. June 17.
Results of the first boll weevil status examination made by agents for the Bureau of Entomology during 1908.

1926 - Anonymous. Outstanding entomological features in the United States for November and December 1925 and January 1926. Insect Pest Surv. B. 6(1):24. Mar. 1. Wash.
A summary is given of reports received from various States outlining the conditions with regard to the more important insect pests, with a view to assisting workers to plan their programs for the coming spring and summer. The pests dealt with include Anthonomus grandis.

1931 - Grossman, E. F. Methods for making counts of boll weevil infestation. Fla. Agr. Expt. Sta. B. 241, 22p.
A survey of half an acre of a field of cotton, in which all squares on all plants were examined, indicated that the greater the number of squares examined, the more closely the estimated percentage of infestation by Anthonomus grandis Boh. approaches the actual degree of infestation in lightly infested fields. Heavily infested fields, however, require the examination of relatively few squares. Of the various methods of determining the degree of infestation, that of making estimates from 20 plants at random is as satisfactory as any other and involves comparatively little labor. The determination of the number of boll weevils in a sparsely populated field is attended with great errors, regardless of the method employed.

1933 - Gaines, J. C. Reliability of differences between data obtained in cotton insect investigations. J. Econ. Ent. 26(1):274-279.
The results indicate that the mean difference between the point and survey methods used in estimating infestation by the boll weevil is not significant.
The point system consisted of examining 100 squares at 36 different points. This was a point to every 29 acres.
The survey method consisted of examining from 25 to 50 squares at 378 points while working through the cuts in a somewhat circling course. This was one point to about every 2 acres. The data for both systems was taken from a 1,034-acre field on the same day.

LOSSES CAUSED BY THE BOLL WEEVIL

1904 - North, S. N. D. Quantity of cotton ginned in the United States (crops of 1899 to 1903, inclusive). U. S. Dept. Com. and Labor, Bur. Census B. 10:9, 15-17.
Statement regarding distribution and loss due to the boll weevil.

1905 - Sanderson, E. D. The boll weevil and cotton crop of Texas. Tex. Dept. Agr. 28 p., 7 pl. Austin.
The author reviews previous estimates which have been made since 1894 of the amount of damage done by the boll weevil.

Statistics were collected on the cotton acreage of Texas from 1899 to 1904 and on the variations in the acreage and in the yields which may be attributed to the work of the boll weevil. In connection with this discussion, maps are presented showing the distribution of the weevil. It is believed that since its introduction into Texas, the boll weevil has destroyed 2,000,000 bales of cotton with an estimated value of one hundred million dollars. The weevil is seldom extremely injurious in the southern part of Texas if stubble cotton is not allowed to remain over winter. Apparently the weevil does not promise to become very dangerous in western cotton counties.

1906 - Cook, M. T. Insects of the year in Cuba. U. S. D. A. Bur. Ent. B. 60:70.
Mention of damage in Cuba during 1905.

1906 - Sanderson, E. D. National control of introduced insect pests. U. S. D. A. Bur. Ent. B. 60:99.
The loss due to the boll weevil is given as illustrating the advantage which would be gained by having national control of insect pests.

1909 - Anonymous. The boll weevil. A. Norden & Co., 15 p. Feb. New York.
A statistical study of boll weevil damage.

1910 - Olmsted, Victor H. Causes of cotton damage in 1909. Crop Reporter, v. 12(12):94. Dec. 14.
A loss of 14.9 percent of the crop of 1909, or 1,267,000 bales, is attributed to the boll weevil.

1910 - Rosenfeld, Arthur H. Insects notably injurious in Louisiana during 1908 and 1909. J. Econ. Ent. 3(2):212.
Practically the entire cotton area of Louisiana, embracing some 34,000 square miles, is now infested with the boll weevil. As a result the cotton acreage of the State has been much reduced, and Louisiana made the shortest crop in all of her history--about 273,000 bales, against 517,000 in 1908, 610,724 in 1907, and 769,222 in 1906.

1911 - Marlatt, C. L. Need of national control of imported nursery stock. J. Econ. Ent. 4(1):108.
Contains statement that loss chargeable to the boll weevil amounts to $25,000,000 a year.

1914 - Howard, L. O. Report of the entomologist for the year ended June 30, 1914. U. S. D. A. Ann. Rpt., Wash.
In 1913, 17,700 square miles of new territory were infested by the cotton boll weevil and the primary loss in the cotton area was approximately $30,000,000.

1914 - Worsham, E. L. The Mexican cotton boll weevil. Ga. State Bd. Ent. B. 39, 24 p., 1 fig., 7 pl. Feb. Atlanta.
In Texas, in 1901, the loss from this weevil in 32 infested counties was 100,920 bales; in 1904, it had increased to 550,000 bales.

1916 - Coad, B. R., and R. W. Howe. Insect injury to cotton seedlings. J. Agr. Res. 6(2):129-139, 3 pl. Apr. 17. Wash.
"Field examination showed that an average of 8% of the plants were deformed and that these averaged 2.6 squares per plant less than the normal about the middle of June, involving a loss of over 1,500 squares per acre at the critical period in cotton production in the presence of boll weevils."

1916 - Worsham, E. L. Ga. State Bd. Ent. B. 44. Mar. Atlanta.
Annual losses from the weevil in other cotton growing States are discussed.

1917 - Mackay, A. H. Ent. Soc. Nova Scotia Proc. for 1916. (2):7-9. Jan. Iruro.
"The cotton boll weevil is responsible for injury amounting to 30 million dollars."

1921 - Ballou, H. A. Cotton crops and cotton pests. Agr. Res. 20(511):378-379. Barbados.
It is said that the shortage in the American cotton crop in 1921 amounts to 7,000,000 bales, of which 25% is directly attributable to the boll weevil.
"The severity of the attacks of A. grandis is greatly influenced by the weather. In Mexico, cotton can be profitably grown in certain dry areas, but in the more humid districts that encourage the development of the weevil, cotton growing has to be abandoned. In the United States, a very severe winter followed by a hot dry summer would result in only slight infestation and a better crop, while the reverse conditions are likely to result in severe infestation."

1924 - Hunter, W. D. Methods of estimating boll weevil losses. J. Econ. Ent. 17(2):195-197.
Probably more attempts have been made to estimate accurately the losses due to boll weevil than have been made in the case of any other insect. Such estimates have been made by entomologists, crop reporters, and commercial organizations. By far the most accurate estimates have been found to be those made by entomologists. A very accurate estimate can be made by comparing production of plots treated with calcium arsenate with untreated plots. The difference in the production is a precise measure of the amount of damage caused by the weevil. The usefulness of this method could be greatly increased by test plots provided by State entomologists in different parts of their States. Estimates made by crop reporters have been found to show a strong trend toward exaggeration. Those made by commercial organizations are frequently colored by market conditions.

1926 - Schaub, I. O. North Carolina boll weevil program for 1926. N.C. Ext. Serv. Folder 17.
Contains charts showing damage by boll weevil to the cotton crop in several southern States for several years following the year when the boll weevil had covered each State.

1928 - Anonymous. Insect pests in Mexico--May-September 1928. Bol. Mens. Defensa Agr. Sec. Agr. Fom. 2(6-7, 8-9):323-361, 488-583. S. Jacinto, D.F. Mex.
The insects mentioned in this report include Schistocerca paranensis F., which increased in some districts, Anthonomus grandis Boh., and other pests of cotton which caused losses in the Lagunera cotton districts that are estimated to amount to over 1,000,000 pounds in 1928.

1928 - Leiby, R. W. Cotton boll weevil damage during 1927. J. Econ. Ent. 21(1):151.
The year 1927 was one of marked damage to cotton by the boll weevil. It was therefore thought advisable to compile the estimates of damage in the different States so that the apparent monetary value of the cotton destroyed would be recorded.
The damage resulted because of a successful winter survival of weevils that was above the average, and a fairly favorable season for development. The damage throughout the cotton States was unusually heavy in spite of a generally favorable cotton growing season.
In Texas the damage was 3% or 132,371 bales; in Louisiana, 20% or 136,250 bales; in Mississippi, 15% or 216,176 bales; in Florida, 40% or 15,075 bales; in Arkansas, 17% or 200,723 bales; in Georgia, 40% or 733,333 bales; in South Carolina, 30% damage or 315,000 bales; and in North Carolina, 27% or 317,000 bales. The States of Alabama, Oklahoma, and Tennessee, which are rather heavy cotton producers, are not included but losses were rather heavy in Alabama, the largest producing State of those not listed here. Estimates of damage have been compiled for individual States in the cotton growing area. The reduction in these States as a whole is estimated at over two million bales, of a value of over $200,000,000.

1929 - Thomas, F. L. What does the future hold in store for the South. J. Econ. Ent. 22(5):736-743.
Average reduction for the period 1921-1925, chargeable to the boll weevil, was 17.3% in cotton.

1929 - Hough, H. W. Our crop destroying insect pests. Sci. Amer., v. 141:125-127. Aug.
Among insects taken up is the boll weevil. About 90% of the cotton producing area of the United States is infested with the pest, which destroys more than 200 million dollars worth of our cotton annually.

1930 - Coad, B. R. The entomologist in relation to cotton insect problems of today. J. Econ. Ent. 23(4):669.
A chart is presented giving estimates of boll weevil and other insect damage to cotton crops for the years 1910 through 1928.

1934 - Hinds, W. E. Presidential address: Some achievements in economic entomology. J. Econ. Ent. 27(1):43.
A figure of $200,000,000 is presented as an estimated annual loss from boll weevil damage.

1954 - Anonymous. 34-year record shows insecticides increase cotton yield an average of 25 percent. U. S. D. A. Press release. May 11.
More than 30 years of insecticide field trials at Tallulah, La., carried on by the Agricultural Research Service, have resulted in an annual average seed cotton yield of 1,826 pounds per acre--371 pounds, or 25.5%, more cotton than from untreated cotton plots, which averaged 1,455 pounds per acre.

1954 - Shepard, H. H. Cotton insecticides. Agr. Chem. 9(1):40-43, 111, 113, 115. New York.
Contains data on losses due to the boll weevil.

1955 - Butler, Eugene. Two bugs that steal cotton--Our fight to stop them. Progressive Farmer (Tex. Ed.) 76:30-31. June.
The first few years after the boll weevil invaded a new area, cotton production dropped from a third to a half, Louisiana, 42% in 1909; Mississippi, 33% in 1913; Florida, 40% in 1919; Alabama, 36% in 1920; Texas, 34% in 1921; Oklahoma, 41% in 1921; Georgia, 45% in 1921; Tennessee, 34% in 1921, South Carolina, 40% in 1922; Arkansas, 25% in 1950; and North Carolina, 34% in 1950.
In 1910, 18 years after the weevil entered the lower valley, it had cut the yield for the Cotton Belt 6 percent, representing a loss of 740,000 bales.
In 1910, the USDA reported loss of 400,000 bales in 1908, value $20,000,000. In 1909 damage was estimated at $15,000,000. In 1921 yield reductions for the Cotton Belt as a whole were 31.2%. The 5-year period, 1918 to 1923, was the most destructive in cotton history, damage averaging 21.3% per year.
Losses estimated by the National Cotton Council starting with 1927 ranged from $63,000,000 in 1931 to $762,757,000 in 1950. For 50 years the weevil's average annual total has been $200,000,000. So the pest has fairly earned the title of 10-Billion-Dollar Bug.

1958 - Coker, R. R. The impact of the boll weevil on cotton production costs. Cotton Gin & Oil Mill Press 59(26):22-24.
Contains information on losses in yields of cotton attributable to the weevil. From 1909 to 1954 it is estimated that 64,877,000 bales of cotton and 27,917,000 tons of cotton seed valued at $7,680,000,000 were destroyed by the weevil.

1959 - Parencia, C. R., Jr. Comparative yields of cotton in treated and untreated plots in insect-control experiments in central Texas, 1939-1958. J. Econ. Ent. 52(4):757-8.
In insect control experiments conducted in central Texas over the 20-year period, 1939-1958, the average increase in yield in treated over untreated plots

was 309 pounds of seed cotton per acre or 42%. The insects of primary importance were the boll weevil (Anthonomus grandis Boh.) and the bollworm (Heliothis zea (Boddie)). The cotton fleahopper (Psallus seriatus (Reut.)) was involved in many years and the cotton aphid (Aphis gossypii (Glov.)) was of considerable importance until after the mid-1940's when several chlorinated hydrocarbon insecticides other than DDT were available.

QUARANTINE

1904 - Connel, J. H. The weevil fight. Farm & Ranch 23:21. May 21.
Urges the planters of northern Texas to drive back the weevil by destroying isolated colonies. Remarks on quarantine.

1904 - Wilcox, E. M. The Mexican cotton boll weevil. Ala. Agr. Expt. Sta. B. 129:91-104, 4 fig. Auburn.
A copy is given of an Alabama law for preventing the importation of seed from cotton affected with the boll weevil.

1905 - Hunter, W. D. The control of the boll weevil, including results of recent investigations. U. S. D. A. Farmers' B. 216, 32 p., 5 fig.
Contains information on the present territory infested by the boll weevil and State quarantine laws against the importation of the boll weevil. Such laws now exist in Alabama, Georgia, Louisiana, Mississippi, North and South Carolina, and Oklahoma. Suggestions are made regarding the desirability of a uniform State law for the control of the boll weevil.

1905 - Newell, W. The Mexican cotton boll weevil. Ga. State Bd. Ent. B. 12:29, 21 fig.
The quarantine law of Georgia regarding the boll weevil is noted.

1905 - Newell, W. Report of the Secretary of the Louisiana Crop Pest Commission, 1904-05. La. Crop Pest Comn. C. 7:27.
Brief statements are presented regarding the boll weevil quarantine in Louisiana, experiments with cultural methods, Paris green, and other means of controlling the boll weevil.

1908 - Newell, Wilmon. The boll weevil. La. State Crop Pest Comn., 2d Bien. Rpt. of the Secy. 1906-1907:9-16, & app.
Report of the work of the commission during 1906-1907. Brief discussion of spread of weevil and quarantine regulations which were enforced up to Feb. 4, 1908, when the quarantine was entirely repealed.

1909 - Herrick, G. W. The insect pest law. Miss. Agr. Expt. Sta. C. p. 7, 1 fig. June 1908.
The inspection law enacted by the legislature of 1908 is given and explained. This law empowers the entomologist of the experiment station to promulgate such rules and regulations in regard to the inspection, transportation, and sale of nursery stock as he may deem necessary and also to make and enforce rules and regulations regarding the boll weevil. The rules and regulations governing the transportation of cotton seed in the State are given.

1912 - Cunningham, T. Inspection of fruit for pests. Br. Columbia Ent. Soc. Proc. p. 50-71.
Provides examples of quarantine orders by various States of the Union against various insects, including Anthonomus grandis (cotton boll weevil).

1913 - Bentley, G. M. Eighth annual report of the State entomologist and plant pathologist for 1912. Tenn. State Bd of Ent., 64 p., 9 fig., 4 m. Knoxville.
"The report contains remarks on the quarantine regulations against the Mexican cotton boll weevil (A. grandis)."

1914 - Hunter, W. D. Quarantine against the Mexican cotton boll weevil. J. Econ. Ent. 7(2):234-240.

The author recapitulates the specific points in the life history of the Mexican cotton boll weevil which justify legislation against it. He is of the opinion that prohibition established by specific laws, on account of its inflexibility, is more unsatisfactory than regulations formulated by boards under general authority, which are better suited to the needs of individual localities. A summary is given of the restricted or prohibited articles in the different southern States.

In support of the prohibition system, the author states that since it has been in practice, no sporadic outbreaks of the weevil have occurred in districts beyond its range of flight from already infested districts. It is therefore likely that many introductions have been prevented and that the resulting good far exceeds the temporary interference with shipping that the restrictions have caused.

1914 - Maskew, F. A leak in our quarantine. Calif. State Comn. Hort. Mo. B. 3(11): 465-467. Nov. Sacramento.

Short illustrated article pointing out that the cotton crop of California--at present free from insect pests and diseases--should be protected from the cotton boll weevil and the pink bollworm by legislation enforcing quarantine and inspection of postal packets, since cotton seed is sometimes sent by mail.

1916 - Worsham, E. L. Boll weevil quarantine regulations. Ga. State Bd. of Ent. C. 19, 11 p., 1 map. July. Atlanta.

Contains the text of the boll weevil quarantine regulations issued by the Georgia State Board of Entomology under authority of the Georgia-Quarantine Act. The boll weevil line extends along points where weevils were actually found at the time of the first killing frost in 1915. The inspection of the U.S. Bureau of Entomology in Alabama, Georgia, and Florida confirmed the correctness of this line. The safety line is 20 miles and the quarantine line is 50 miles in advance of the actual boll weevil line. No person except the State entomologist or his authorized deputy may lawfully have in his possession outside of the weevil infested territory any living stage or any cotton square or boll containing such stage of the Mexican cotton boll weevil.

1917 - Anonymous. Reports of County Horticulture Commissioners. Calif. State Comn. Hort. Mo. B. 6(11 and 12):415-482. Sacramento.

"The cotton boll weevil (A. grandis) and the pink bollworm (Pectinophora gossypiella) have so far been rigorously excluded."

1918 - Hecke, G. H. Cotton boll weevil Amendment No. 2 to Quarantine Order No. 26. Calif. State Comn. Hort. Mo. B. 7(1 and 2):110. Sacramento.

As the cotton boll weevil is not known to exist in the State of Arizona and the State has, therefore, declared and is maintaining a quarantine against the entrance of this pest, it is declared that, until further orders, cotton seed grown in the County of Yuma, Ariz., may be imported into California, subject to the following regulations: Persons contemplating the importing or bringing into the State of California cotton seed grown in the County of Yuma, Ariz., shall first make application for a permit to do so, stating the name and address of the exporter, the locality where the seed was grown, the amount of importation, and the name and address of the importer in California. They must also obtain a certificate in triplicate signed by the Entomologist of the State of Arizona, stating locality where cotton seed was grown.

All quarantine orders or regulations promulgated for the protection of the cotton industry in the State of California are also directed against A. grandis var. thurberiae and the pink bollworm.

1918 - Maskew, F. A record of six years' work. Calif. State Comn. Hort. Mo. B. 7(9):521-522. Sacramento.

A list of some of the more destructive insects that have been kept out of the State of California by means of its quarantine system during the years 1912-1918 includes: . . .Mexican cotton boll weevil.

1918 - Morrill, A. W. Insect pests of interest to Arizona cotton growers. Ariz. Agr. Expt. Sta. B. 87:173-205, 1 pl., 29 fig. Dec. Tucson.

"Quarantine Order No. 215 directed against the introduction of A. grandis and Pectinophora gossypiella into Arizona is quoted in full."

1918 - Worsham, E. L. Boll weevil quarantine regulations. Ga. State Bd. Ent. C. 25, 11 p., 1 map. Jan. Atlanta.

In 1917 the damage caused by the boll weevil in Georgia amounted to from 25% to 75% of the crop. A map showing the infested area and the determination of the 20-mile safety line is given. The regulations governing transportation of cotton seed, seed cotton, bolls, seed cotton and cotton pickers' sacks, and related items, directed against the spread of this pest, are recapitulated and brought up to date.

1919 - Anonymous. Progress in the chief industries--cotton. Agr. Dept. St. Vincent Rpt. 1917-1918: p. 15-19. Barbados.

"An important Order-in-Council was published on July 25 under the Importation of Plant Diseases Prevention Ordinance (1906) prohibiting the importation of cotton seed and seed cotton into the colony from an outside source. Though primarily intended to prevent the introduction of the Mexican cotton boll weevil and pink bollworm, it also aimed at the exclusion of certain pests and diseases occurring in other parts of the West Indies, but not found locally."

1919 - Newell, W. Report of the plant commissioner for the biennium ending April 30, 1918, and supplemental reports. Fla. State Pl. Bd. Q. B. 3(2):33-108. Gainesville.

"The area in Florida infested by the cotton boll weevil (A. grandis) has gradually increased southward and eastward owing to the migration of the adults by flight, a spread that cannot be prevented and that results in the insect invading new territory each year. The enforcement of quarantine measures, however, which prohibit the removal from weevil-infested territory of cotton seed, seed cotton bolls, Spanish moss, maize on the cob, and certain other materials, except at certain seasons and under certain conditions, has undoubtedly prevented the establishment of the pest ahead of the advancing line of migration."

1920 - Hecke, G. H. California--A future cotton State. Calif. State Dept. Agr. Mo. B. 9(1-2):3-4. Sacramento.

To insure the future success of cotton growing in California, the necessity of carrying out the inspection and quarantine service on a more adequate scale is emphasized. So far the cotton boll weevil and the pink bollworm, Pectinophora gossypiella, have not gained entry into the State.

1921 - Anonymous. Departmental activities: entomology. J. Dept. Agr., U. So. Africa. 3(3):208-210. Pretoria.

Attention is drawn to the permits that are necessary in respect of importations of cotton seed. Permits are given only for seed to be sown, and then only to the extent of 10 lbs. of a variety to any one applicant. The importance of these restrictions has been indicated several times in the past year by the finding of the pink bollworm (Platyedra gossypiella) in small parcels of North African seed, and, during the past month, by the presence of a few dead adults of the Mexican boll weevil in a parcel of seed from the United States.

1921 - Anonymous. Quarantine proclamation No. 82. Australia Commonwealth Gaz. Extract 43. May 12.

By a proclamation dated May 6, 1921, under the Quarantine Act 1908-1920, the introduction into Australia is prohibited of the following insects: Attagenus undulatus Motsch (khapra beetle), Pyrausta nubilalis Hb (European corn borer), Platyedra (Gelechia) gossypiella (pink bollworm), and Anthonomus grandis (Mexican boll weevil).

1921 - Strong, L. A. Report of the Bureau of Plant Quarantine. Calif. Dept. Agr. Mo. B. 10(11-12):614-626. Sacramento.

The work of the Plant Quarantine Service of the U. S. D. A. during the year ending June 30, 1921, is reviewed, and particulars are given of inspection at the various stations. The conclusion is reached that if an adequate measure of protection is to be given against such serious pests as the cotton boll weevil, pink bollworm, and others that are liable to be introduced through interior points and at border points, a sufficient number of inspectors must be provided to insure thorough inspection at the border lines and all terminals.

1921 - Catoni, L. A. Dos plagas del algodon que no queremos en Puerto Rico (Two cotton pests that are not wanted in Puerto Rico). P. R. Insular Exp. Sta. C. 4, 9 p. Apr. Rio Piedras.

The Puerto Rico Department of Agriculture requests all cotton growers to cooperate in guarding against importing into the Island any cotton seed proceeding from countries where the cotton boll weevil or Platyedra (Pectinophora) gossypiella (pink bollworm) occur.

1921 - Cantoni, L. A. Plant inspection and quarantine report (1919-20). P.R. Insular Expt. Sta. B. 27, 23 p., 4 tab. Rio Piedras.

A description is given of the setting up in 1919 of a Technical Board to supervise Plant Quarantine and Inspection. In January, boll weevils were found in some unlawfully imported cotton seed, but there was no trace of the pest in the area planted before inspection.

1922 - Mote, D. C. Biennial report of the State entomologist. Ariz. Comn. Agr. & Hort. 12th & 13th Ann. Rpts. 1919-1921:17-64, 9 fig., 2 maps, 6 tab., Phoenix.

The work of the various inspection services for 1920 and 1921 is reviewed. The quarantine and other measures adapted against the Mexican cotton boll weevil are given.

1922 - Mote, D. C. Report of Arizona conditions. Calif. Dept. Agr. Mo. B. 11(8-9): 625-628.

The general lines of work for safeguarding the cotton crop in Arizona are outlined. The quarantine against boll weevil and pink bollworm (Platyedra gossypiella) is enforced with great thoroughness, inspection being made of all packages entering by post, rail, or road. In a portion of Pima County a noncotton zone was declared in November 1920, and was so successful that in 1921 a small patch of selfsown cotton and a plot allowed to grow for observation purposes were the only spots in which living weevils were found. The noncotton zone was continued in 1922.

1923 - Fletcher, T. B. Report of the imperial entomologist. Pusa, India. Sci. Rpts. Agr. Res. Inst., 1921-1922:51-67, 3 pls., 1922. Calcutta.

"There is considerable danger of Anthonomus grandis (boll weevil) being introduced from America and of other pests from Uganda. The situation is being watched."

1923 - Froggatt, W. W. Insect pests of the cultivated cotton plant. New South Wales Agri. Gazette, No. 2, 34(1):61-64, Jan. 1. Sydney.

A brief account of Mexican cotton boll weevil and Platyedra (Gelechia) gossypiella (pink bollworm), the two great cotton pests of the world. These pests might easily be accidentally introduced into Australia either in the cotton seed or in unginned or badly ginned cotton, and it is only by the total prohibition of all seed from the countries where they exist and by careful examination and treatment of all seed from elsewhere that they can be kept out of the Commonwealth.

1924 - Anonymous. Departmental activities: Entomology. J. Dept. Agri., U. of So. Africa 9(5):378-379.

A dead specimen of the Mexican cotton boll weevil was found in imported cotton seed from America covered by an official overseas inspection certificate

and treated twice for the destruction of insects before reaching South Africa. This shows how easily a formidable pest might be introduced into a country were drastic precautions not exercised.

1924 - Fletcher, T. B. The American cotton boll weevil--A menace to India. Pusa, India. Rpt. Proc. Fifth Ent. Meet., 1923:58-64. Calcutta.
Owing to the possibility of the American cotton boll weevil obtaining a footing in India, attention is drawn to its habits and to the enormous loss it causes to the cotton crop in America. The probability of its introduction into India has been accentuated recently by the large importations of American cotton.

1924 - Jacobsen, W. C. Bureau of Plant Quarantine and Pest Control. Calif. Dept. Agr. Mo. B. 13(7-12):156-161.
"During the year additional border inspection stations were opened at which cotton seed, cotton bolls and other carriers of the cotton boll weevil (A. grandis) were frequently intercepted."

1924 - Urbabus, T. D. Field Entomology. Calif. Dept. Agr. Mo. B. 12(7-12):161-164.
"Anthonomus grandis (cotton boll weevil) has not yet been found in California."

1925 - Anonymous. Proceedings of the sixth conference Western Plant Quarantine Board, Denver, Colorado, May 10-24, 1924. Calif. Dept. Agr., Spec. Pub. 54, 100 p., Sacramento.
"As a result of road inspections live adults and larvae of A. grandis (Mexican boll weevil) were found in several lots of cotton bolls from infested territory."

1927 - Anonymous. Libya, decree of September 13, 1926, on importation of plants. Internatl. Rev. Sci., and Pract. Agr. 18(3):T187-T188, Apr. Rome.
These regulations on the importation of plants into Libya include almost identical prohibitions to the Italian ones regarding insects. The importation of plants and seeds of cotton from the United States, Mexico, Central American countries, and Egypt is prohibited against Anthonomus grandis.

1927 - Anonymous. Quarantine proclamation, No. 176. Austral. Commonwealth Gaz. No. 125, reprint 1 p., Nov. Melbourne.
The importation into Australia of cottonseed or cotton lint is prohibited except that cottonseed for planting may be imported at Brisbane only and by permission of the Minister of Health, and cottonseed, imported for crushing into oil and meal, must have originated in a country where pink bollworm, or the Mexican boll weevil are known not to exist. Raw cotton may be landed only at Sydney, Melbourne, Adelaide, Fremantle, Launceston, or any port, other than at Queensland, approved by the minister, and must be disinfected before being released from quarantine.

1929 - Panteleev, A. M. The organization of quarantine to prevent the introduction from abroad of pests of cotton into U.S.S.R. (In Russian). Khlopkonoe Delo 8(12): 1437-1455.
The economic importance of the Mexican cotton boll weevil is briefly discussed, and notes are given on the history of the organization of the quarantine service in Russia, which was inaugurated in 1914.
The work carried out in 1929 included further investigations on cotton pests in Persia and the establishment in Central Asia and Transcaucasia of a permanent quarantine inspection service. A vacuum apparatus has been ordered for the custom house in Markar for the fumigation of cotton imported from the Igdir region; and preliminary work has been carried out in connection with the organization in Leningrad and Odessa of a service for the disinfection on a large scale of cotton seeds arriving from Egypt and America, especially in view of the fact that in the latter country seeds from areas severely infested with A. grandis are not being disinfected prior to export.

1932 - Anonymous. Legislative and administrative measures. Int. Rev. Agr. 26(9): M146-M153.

An order issued by the Spanish Ministry of Agriculture, dated April 20, 1932, prohibiting import of plants, plant parts, or products of other materials capable of carrying Anthonomus grandis Boh. into the country.

1934 - Fleury, A. C. Monthly bulletin. Calif. Dept. Agr., Bureau of Plant Quarantine 22(12):526-535.

Pests intercepted in California during 1933 in the course of quarantine inspection at major ports included Anthonomus grandis Boh. in seed cotton from Virginia.

1937 - Anonymous. A proclamation. The Plant Protection Ordinance, 1935, 1 p. Kingston, St. Vincent.

In virtue of the Plant Protection Ordinance No. 14, of 1935, the importation into St. Vincent from Haiti, Santo Domingo, Cuba, Mexico, Central American and the Southeastern States of the United States of America of articles, including any that have been declared by the Agriculture Authority to be infested or suspected of being infested by Anthonomus grandis Boh., all malvaceous plant material, and all agricultural produce, is absolutely prohibited.

1940 - Adamson, A. M., and R. E. D. Baker. The work of the British West Indies Plant Quarantine Station from 1934-39. Trop. Agr. 17(1):4-5, Trinidad.

An account is given of the organization, methods, and work of the British West Indies Plant Quarantine Station, which is situated near Port-of-Spain, Trinidad. The Station, which was established in 1934, serves all the British West Indian Islands and also British Guiana and British Honduras. The chief plants dealt with are sugarcane, cotton, banana, and citrus. Satisfactory treatment for cotton seed has been developed. On arrival, it is treated with strong sulphuric acid, heated to 60°C. for a half hour, and then grown for one generation in a special quarantine house. Seed to be sent away is heated or fumigated, but not treated with sulphuric acid. Many insects, including bollworms, have been intercepted in cotton seed.

Legislation has been planned to prevent the introduction of the cotton boll weevil into the British West Indies. It was introduced from the American mainland into Cuba and in 1933 was found in Haiti, where it has become extremely destructive. Its further spread into the Lesser Antilles might put an end to the commercial production of cotton in these islands.

MISCELLANEOUS

1895 - Howard, L. O. Mistakes about the cotton boll weevil in Texas. U. S. D. A. Insect Life, Div. Ent. 7:362-363. July.

The seriousness of the pest being overlooked on account of the application of the term "sharpshooter" to the boll weevil. Mentions insect breeding in bolls in abundance.

1897 - Howard, L. O. The Mexican cotton boll weevil in 1897. U. S. D. A. Div. Ent. C. 27 (second series), 7 p.

Investigations conducted in southern Mexico and the unsuccessful attempt to find any weevil parasites there. Extent of injury and spread of the pest during 1897. Possibility of spreading the weevil in seed cotton and cottonseed. A machine designed to apply dry poisons, and the value of domestic fowls as weevil destroyers. Remedies as given in C. 18 of the Bureau of Entomology are briefly reiterated.

1903 - Howard, L. O. The Mexican cotton-boll weevil. Science. n.s. 18(465):693.

Notes are given on the investigation of this insect which was begun by the Division of Entomology in 1894 and which has led to the discovery of a method by which a fair crop of cotton can be raised under conditions of infestation by this insect.

1904 - Fuller, C. Cotton insects and fungus blights. Natal Agr. J. and Min. Rec. 7(10):931-944, 16 fig. (Reference taken from Expt. Sta. Rec. v. 16:680.)
The habits, life history, natural enemies, and means of combating cotton boll worm, cotton worm, Mexican cotton boll weevil, cutworms, plant lice, as well as rust mildew, angular spot, pink spot, and cotton boll rot.

1905 - Froggatt, W. W. The cotton boll weevil. New South Wales Agr. Gaz. 16:23-25, 2 fig.
Habits, life history, and injurious attacks of this species. The possibility of its being introduced into Australia is suggested. Brief history of its spread and of parasites attacking the species.

1905 - Herrick, G. W. The Mexican cotton-boll weevil. Miss. Sta. C. 17:7, 2 fig.
Origin, appearance, life history, and injurious attacks of this species, and danger of importing the pest into Mississippi.

1905 - Sanderson, E. D. Insects mistaken for the Mexican cotton boll weevil. Tex. Sta. B. 74:13, 5 pl., 7 fig.
The difference between the appearance of the cotton boll weevil and that of various other insects which have been mistaken for it. Among the latter, mention is made of Lixus sylvius, Tricholaris texana, whitoepine weevil, Hylobius pales, snowy-tree cricket, plum curculio, plum gouger, Chalcodermus aeneuso, Notoxus calcaratus, Drasterias elegans, and a considerable number of other insects which were found on cotton and other cultivated plants.

1905 - Sherman, F., Jr. The cotton boll weevil. N. C. Dept. Agr. Ent. C. 14:11, 5 fig.
The introduction, appearance, life history, and habits of this insect, in connection with their bearing upon the distribution and economic importance of the pest. The remedies recommended by the Division of Entomology of the U. S. D. A. are believed to be the most effective in controlling the weevil.

1905 - Galloway, B. T. Work of the bureau of plant industry in meeting the ravages of the boll weevil and some diseases of cotton. U. S. D. A. Ybk, 1904:497-508.
The work of the Bureau in this field is briefly outlined under the heads of plant breeding, tropical cottons, diseases of cotton, diversification farms, co-operative demonstration farms, early maturing varieties of cotton, and farmers' institute work. Considerable improvement in farm economy has been noted as a result of these investigations.

1907 - Hunter, W. D. Some recent studies of the Mexican cotton boll weevil. U. S. D. A. Ybk, 1906:313-324.
The status of the cotton boll weevil in 1906; local variations and their causes; the relation between weevil damage and precipitation; factors in the natural control of the boll weevil; additional data concerning importance of fall destruction of cotton stalks; late planting.

1907 - Dugeon, G. C. Insects and other cotton pests, and the methods suggested for their destruction. B. Imp. Inst., 5(2):141, 161-163.
Resumé of various writings on the boll weevil. Discussion of amount of damage, life history, habits, enemies, and remedial measures.

1907 - Mayer, August. The most important factor in solving the boll weevil problem. La. State Crop Pest Comn. Cir. 16, 8 p., June 20. Aug.
Relation of the cattle tick to the boll weevil problem. Particular stress is placed upon the necessity of eradicating the cattle tick, so as to enable the cotton growers of the South to raise cattle profitably, and thus have the manure to increase the productivity of the soil.

1909 - Newell, W. Third biennial report of the secretary for the years 1908-09. La. Crop Pest Comn. Bien. Rpt. 3 (1908):24.
A report of the work of the year on the Argentine ant, boll weevil, San Jose scale, and other insect pests.

1909 - Froggatt, W. W. Report on parasitic and injurious insects in various parts of the world in 1907-1908. Rpt. of the Govt. Ent., Dept. of Agr., N. S.Wales, p. 18-19, 23, 62-63.

Work on the boll weevil by the U. S. D. A. and the Crop Pest Commission; also area devoted to cotton in Mexico and presence of boll weevil. Brief history of spread of weevil and of parasites attacking the species.

1910 - Hinds, W. E. Facing the boll weevil problem in Alabama. Ala. Col. Sta. B. 146:79-102, 2 pl., 1 fig.

The life history and habits of the boll weevil, the nature of its injury, and methods of control. If the rate the weevil has been traveling eastward is maintained, the general line of infestation may be expected to reach the Mississippi-Alabama boundary by November 1910.

Movement of boll weevil since its spread into Texas in 1892. Quarantine regulations, description, effect on cotton, and method of cultural control of boll weevil. Hope that the coming of the boll weevil shall bring a blessing to the State and not be a curse.

1911 - Bishopp, F. C. An annotated bibliography of the Mexican cotton boll weevil. U. S. D. A. Bur. Ent. C. 140:30.

Some 297 titles are intended to serve as an index to the extensive literature on the Mexican cotton boll weevil.

1914 - Hinds, W. E. Boll weevil effect upon cotton production. Ala. Agr. Expt. Sta. B. 178:87-99, 1 map. July. Auburn.

The boll weevil has spread steadily at an annual rate of 50 miles since 1891, when it entered from Mexico. This progress is due to the adaptability of the cotton plant to a more northern climate than that in which it originated. The degree of damage by the boll weevil, however, will not be uniform throughout the cotton area, owing to the smaller number of generations in cooler and drier portions of the cotton belt. For example, in northern Texas (33° N. lat.) there is one generation less than in southern Texas (29° N. lat.).

By far the most important factors in natural control are climatic conditions, extremes of heat and drought, particularly so when they occur at the beginning of the fruiting season and continue for 6 weeks or more. Extremes of cold and wet in winter have occasionally exterminated the weevil; this happened in Central Arkansas and northern Mississippi in 1911-1912. In Alabama there is no likelihood of control by heat and drought, although in the mountainous regions in the northeast and north of the Tennessee Valley extreme winter temperature may check the advance of the weevil.

The occasional reduction of the weevil by early frosts demonstrates the possibility of its control by means of a general destruction of stalks in autumn; the general stripping of cotton by the cotton worm has much the same influence in checking multiplication of the weevil.

By studying a map on which the rainfall and boll weevil injury zones are charted, it is possible to determine approximately what degree of damage may be anticipated as the boll weevil advances. This pest may be credited with a large portion of the rise in price of cotton between 1902, when it sold at 5 to 6 cents per pound and 1910, when the price ranged from 10 to 14 cents or more.

Two tables show the effect of this weevil upon the yield of cotton per acre, by 5-year periods in Texas, Louisiana, Mississippi, Arkansas, Alabama, Georgia, and North and South Carolina. The first 4 are classed as infested and the remaining 4 as uninfested States. In 3 half-infested States, the decrease averaged 13.6%, while in Louisiana (wholly infested) the figure was 38%.

The most important factors in natural control are climatic conditions. Rainfall is a factor; where there is 10 inches or less, damage from boll weevil is light. Injury according to rainfall zones is discussed.

In Arizona a variety of the boll weevil (A. grandis var. thurberiae) was discovered on a plant closely allied to cotton and adapted to a dry climate. The periods of hot weather in Texas, should the weevil by any chance be introduced

into that State, would have no effect in controlling it, and the weevil would become a serious pest there.

1917 - Morrill, A. W. Cotton pests in the arid and semi-arid Southwest. J. Econ. Ent. 10(3):307-317.

The more destructive insect enemies of cotton in the Southwestern States, with special reference to their geographical distribution. The species dealt with include the Mexican cotton boll weevil.

A comparison is made between conditions in the arid Southwest, where 23 injurious species are recorded, and the States east of the 98th meridian, where 42 insect pests of cotton are found.

A bibliography of 23 works is given.

1917 - Utra, G. Enfermedales del algodonero (Diseases of cotton). Bogota Agr. Rev. 3(10):592-596. Oct.

This is part of a popular article on 4 insect pests of cotton in Brazil: Alabama argillacea (Hbn), Heliothis obsoleta (armigera), Pectinophora (Gelechia) gossypiella, and Anthonomus grandis.

1918 - Worsham, E. L. Twentieth annual report of the State Entomologist for 1917. Ga. State Bd. Ent. B. 51, 44 p., 3 fig. Jan. Atlanta.

Damage to cotton by A. grandis has on the whole been considerably less than in 1916. Research work on this pest included studies on hibernation, longevity, foodplants, general biology and control. Dusting with arsenate of lead and sulphur was tried, but results were inconclusive.

1919 - Ball, E. D. Economic entomology: Its foundation and future. J. Econ. Ent. 12(1):34, 52-53.

"The cotton-boll weevil depends entirely upon the cotton plant for existence, and if the Americans would store cotton in advance and cease to grow the crop for a single year, its eradication might be accomplished."

(A correction was made in the statement that the cotton boll weevil has only one foodplant. A native wildplant found in the mountains from Guatemala to Arizona serves as a host, while some of the native plants of the South also serve to a limited extent as foodplants. It is possible, therefore, that this pest might survive in spite of a suspension of cotton growing.)

1919 - Caffrey, D. J. The European corn borer problem. J. Econ. Ent. 12(1):101.

"In the course of the discussion following this paper, the boll weevil is quoted as an instance where control measures had been delayed too long with disastrous results."

1919 - Morrill, A. W. Report of the Entomologist. Ariz. Comm. Agr. and Hort. 10th Ann. Rpt., 1917-1918:29-73, 13 fig., 2 pls., 7 tab. Phoenix.

The area under cotton cultivation in Arizona during 1917 was greatly increased, and accordingly pest control became more important. At the present time the alfalfa weevil, the pink bollworm, and the cotton boll weevil are the greatest insect menaces.

The cotton boll weevil did not cause excessive damage.

1921 - Morrill, A. W. Cotton boll weevils. J. Econ. Ent. 14(4):373-374.

A series of cotton boll weevils on the West Coast of Mexico included Anthonomus grandis and A. grandis thurberiae, as well as numerous hybrids between them and races of them. Bolls are apparently preferred to squares for oviposition.

1921 - Watson, J. R. Notes on some Florida weevils. Fla. Ent. 4(3):33-35. Jan. Gainesville.

"Recently collected in Florida, Epicaerus formidulosus Boh., which is commonly found on cotton, where it is frequently mistaken for the boll weevil (A. grandis)."

1921 - Vincens, F. Rapport sonimaire sur les travaux effectues, an laboratoire de phytopathologi del institut scientifigue del indochine dul 1 Janvier 1919 and 1 Juillet 1921. Saigon, Agr. Inst. Sci. B. 3(10):307-323. Oct.

"A weevil, Anthonomus sp., abounds in the flowers and attacks the bolls (cotton); an inquiry was sent to the United States to ascertain if the species is A. grandis."

1922 - Itie, G. Las plagas del algodon en la Comarca Lagunera (Cotton Pests in the Laguna District). Mex. Rev. Agr. 6(9):504-513, 13 fig. Jan.

The information in this paper is largely concerned with Platyedra (Pectinophora) gossypiella (pink bollworm), which is the worst pest of cotton in the Laguna District of Mexico. Of less importance is Anthonomus grandis, which, under normal conditions, can never be a very severe pest in the district. It is endemic in the region and increases in numbers towards the end of autumn.

McDonald, R. E. Report of the entomologist. Tex. Comnr. Agr. 15th Ann. Rpt., p. 32-38. Nov. 1, 1922. Austin.

At the beginning of the season 1921-22 the cotton boll weevil was very abundant throughout Texas, but owing to weather conditions the damage was less serious than had been anticipated.

1922 - Morrill, A. W. Arizona wild cotton or thurberia and its insect enemies in relation to the cotton industry of the Southwest. J. Econ. Ent. 14(6):472-478.

Experience with the cotton boll weevil shows that the maintenance of narrow noncotton zones, as suggested by Arizona officials, does not stop the progress of the weevil. This pest will cross a 5- or 10-mile noncotton zone faster than if it were planted entirely with cotton. Relationships between weevil and foodplant having been disturbed during a critical period and at a place where easily thrown out of adjustment, the outlawed cotton plantings become valuable as trap crops. Under the circumstances the more cotton grown in a prohibited area, the better would be the protection of the more important cotton sections within range of the 2 pests here dealt with, A. grandis thurberiae Pierce and Thurberiphaga catalina Dyar (thurberiae bollworm).

1922 - Newell, W., and E. W. Berger. Insects injurious to the principal crops of the South. Fla. State Plant Bd. Q. B. 6(4):97-116. July. Gainesville.

A brief account of the principal insect pests occurring in the Southern States, including the boll weevil, with recommendations for their control. They are arranged, as far as possible, under their respective foodplants.

1922 - Vayssiere, P. L. Anthonome de cotonnier (Anthonomus grandis Boheman). Agron. Colon. 52 & 53:97-102 & 150-155, 4 pl., 3 fig. Apr. & May. Paris

A general account is given of Anthonomus grandis Boh., in view of the importance of keeping this pest out of the French colonies, where cotton cultivation is being taken up.

1923 - Aigin, I. Mexican cotton boll weevil. Cotton Indust. 2(5-6):54-58. Moscow.

A general account of the injury caused by Anthonomus grandis to cotton in North American States and the remedial measures employed against it. Though this weevil has not as yet occurred in Turkestan where climatic conditions would appear to be unfavorable to its establishment, the possibility of its introduction must not be lost sight of, especially in connection with the importation of American cottonseed.

1923 - Meadows, William R., and William G. Blair. Comparative spinning tests of superior varieties of cotton (grown under weevil conditions in the southeastern States, crop of 1921). S. C. Agr. Expt. Sta. B. 1148. Feb. Clemson.

The cottons tested were from the crop in 1921 and consisted of the fiber of the following: Acala, Lone Star, Mexican Big Boll, Rowden, and of typical cotton of the kind commercially known as "North Georgia." The Acala cotton was

grown in Alabama; the Lone Star, Mexican Big Boll, and Rowden were grown in different parts of North Carolina; and the typical North Georgia cotton was grown in "North Georgia."

All the cottons were tested under identical mechanical conditions.

The grades, lengths of staple, percentages of visible waste, strengths of the yarns, and percentages of average deviation or irregularity of the sizings and strengths indicate that for hard twisted or warp yarns the varieties tested, if placed in order of their merit and attractiveness from a spinner's viewpoint, would fall in the following rank:

1. Acala and Mexican Big Boll - equal.
2. Lone Star and Rowden - equal.
3. North Georgia - typical.

These tests show clearly the desirability, from a spinner's standpoint, of fiber produced by purebred strains of superior varieties of cotton over that produced from commercial seed even when grown in districts in which the reputation for character in cotton is excellent.

1924 - Andres, A. Etwas uber den "boll weevil" (Some notes on the boll weevil). Ztschr. Angew Ent. 10(2):470-472. Oct. Berlin.

A brief resumé of existing information on the cotton boll weevil in the United States.

1924 - Symes, C. B. Insect pests of cotton. Rhodesia Agr. J. 21(2):136-151, 4 pl. Apr. Salisbury.

Cotton is being grown as a new crop in Rhodesia, where over 50 species of malvaceous plants already occur, including some 25 species of Hibiscus, so that many of the well-known pests of cotton are probably present. A short account is given of each of the more usual pests occurring in other countries, with the most successful remedies against them. Neither of the 2 chief pests, Platyedra gossypiella (pink bollworm) or Anthonomus grandis (cotton boll weevil) as yet occur in Rhodesia.

1924 - Vasilev, I. V. Cotton pests. Cotton Indust. 3(7-8):86-116, 37 fig. July-Aug. Moscow.

Anthonomus grandis and Platyedra gossypiella have not yet been recorded, their absence and that of many southern tropical pests being due to the peculiar climatic conditions and methods of cultivation necessitating artificial irrigation.

1925 - Anonymous. Handbook of American Cotton Association boll weevil campaign (season of 1924-25). Amer. Cotton Assoc., 32 p. St. Matthews, S. C.

The losses sustained by the American cotton crops of 1921 and 1922 as a result of attack by boll weevil were estimated at an aggregate of about 200,000,000 pounds. The American cotton association, therefore, undertook the leadership of a general campaign, as a result of which 933 cotton demonstration farms of 10 acres each were established in 1923. The movement was enthusiastically endorsed by growers. These were responsible for the success of the control measures, applied under simple and practical instructions.

Many letters indicating the success of the campaign are quoted. In one of these it is stated that 4 good applications of calcium arsenate will result in a bale of cotton per acre on good land under heavy weevil infestation. With the use of poison, 1,250 lbs. of seed cotton were obtained per acre, whereas from the same type of land without poison only 700 lbs. were produced. Hundreds of farmers testified that the plan of cotton culture and weevil control as applied under the supervision of the Association increased the yield of cotton per acre by 50%. In two years the Association expended nearly $250,000 in field demonstration work in 11 states, and the results obtained have fully justified the expenditure. If all the 800 infested counties of the entire cotton growing area could be covered by demonstrations, as was done in Georgia, S. Carolina, and Alabama, the weevil could be definitely controlled.

1926 - Cassidy, T. P. The Arizona cotton boll weevil problem. J. Econ. Ent. 19(5):772-777.

It was thought that this weevil (A. grandis thurberiae) may be potentially a more serious menace to cotton in the drier regions than either the pink bollworm or the typical A. grandis is in the regions in which they occur. The Arizona weevil prefers bolls for oviposition, so that measures to make a crop mature in advance of the weevil, such as are employed in the South against the typical form, would be of no advantage. The weevil shows an enormous degree of resistance to extreme conditions. It is able to go into a state of at least partially suspended animation whenever conditions become too hot, too cold, or too dry. Hibernation studies showed that about 70% of the weevils survived under conditions about as severe as are ever expected in an area southwest of Tucson, whereas only 2% to 5% of A. grandis survive under normal conditions.

This variety is ideally adapted for transportation.

1926 - Hinds, W. E. Boll weevil control results for 1925. J. Econ. Ent. 19(4):599-600.

The uniform conditions of excessive heat and drought in 1925 in the cotton growing districts of the United States had a remarkable effect on the abundance of the cotton boll weevil. At the beginning of the season the weevils were fairly abundant, but, during the time when they are usually most harmful, they were practically eliminated by weather conditions. In the autumn the numbers increased in some localities, and sufficient weevils hibernated to form a distinct menace in 1926, if weather conditions were normal. Under conditions of 1925, dusting was almost unnecessary. The cotton aphis was more abundant on dusted than on untreated fields.

1928 - Hinds, W. E. Important cotton insects of central Peru. J. Econ. Ent. 21(4):545-551.

A brief investigation of the more important cotton pests in a district about 100 miles south of Lima in central Peru afforded no evidence of the existence there of either Anthonomus grandis Boh. or Platyedra gossypiella Saund.

Anthonomus vestitus Boh. was found from sea level to an altitude of over 2,000 feet. The presence of the adults was betrayed by the flaring and falling of the squares, which drop more quickly after oviposition than those attacked by A. grandis.

1928 - Morstatt, H. Actes du Conseil International Scientifique Agricale. Premiere Session (November 7-12, 1927). Internat. Inst. Agr. Roy. v.II, 754 p. Rome.

The report in v. 2, p. 542-552, by H. Morstatt contains a review of the biology, distribution, and control of the cotton boll weevil.

1929 - Hinds, W. E. The development of a control program for the Mexican cotton boll weevil and some of its results. 4th Internat. Cong. Ent., Ithaca, N. Y. 1928(2): 175-180.

The history of the cotton boll weevil as a pest of cotton and the development of control measures in the United States. Dusting against this pest has been increasingly practiced in the Southern States during the past 10 years, and poisoning is now considered as essential as the use of improved seed or commercial fertilizers. Where the "average" yield of cotton was 1/3 bale per acre, it cost more than 20 cents to produce, whereas in districts where the full program of weevil control and the best cultural measures were applied, the average yield for the past 3 years was practically 2 bales per acre and the total cost was 5 to 9 cents per lb. It is now possible to produce cotton at a greater profit than before the weevil occurred.

1929 - King, W. V. The cotton flea hopper (Psallus seriatus). 4th Internat. Cong. Ent., Ithaca, N. Y. 1928, p. 452-454.

Under ordinary conditions of damage by the boll weevil, the planter often depends on the early part of the crop before the weevils become numerous, and

an almost normal amount of cotton may be produced if no more than an average weevil infestation occurs. If, however, the numbers of early bolls have already been reduced by P. seriatus, the losses become much more important.

1929 - Webb, J. L., and F. A. Merrill. Cotton or weevils. U. S. D. A. Misc. Pub. 35, 16 p. Jan.

A popular article on life history, habits, and control, primarily for high school ages.

1930 - Folsom, J. W. Plant quarantine information. Calif. Dept. Agr. Mo. B. 19(3-4): 201-281, 48 fig., 5 ref. March-Apr. Sacramento.

Includes two articles on some of the more important insect pests that do not occur or are not generally distributed in California, although found in other parts of the U.S.

The articles are: The Mexican and thurberia cotton boll weevil (A. grandis Boh., and A. grandis thurberia Pierce), by J. W. Folsom (p. 212-215).

1932 - Rude, C. S., and C. L. Smith. Observations on a combined boll weevil and pink bollworm infestation in northern Mexico. J. Econ. Ent. 25(4):772-776.

Observations were carried out in 1931 on a heavy infestation of cotton by Anthonomus grandis Boh., discovered in northern Mexico, in conjunction with an infestation by Platyedra (Pectinophora) gossypiella Saund. Weekly records were made of the percentage of square and boll infestations by both species. Multiplication and development of either pest was not checked by that of the other.

1934 - Radzievshaya, S. B., V. I. Serbinov, and S. K. Tzuigankov. Pests and diseases of cotton. A manual for technical schools (In Russian). Demy 8 v., 189 p., 100 fig. Moscow, SAOGIZ (Amalgam. St. Pub. Cent. Asiat. Sect.). (Reference taken from Rev. Applied Ent. v. 22(A) p. 439).

Opens with a general account of the anatomy, morphology, classification, and biology of insects, and of the anatomy and morphology of mites. About 50 pages are devoted to notes on the bionomics and control of the more important insects and mites that attack cotton in the Russian Union; each species is described, and a key to the aphids is included. Further notes are given on Platyedra (Pectinophora) gossypiella Saund., and Anthonomus grandis Boh., in view of the possibility of their introduction into the Russian Union, and the importance of quarantines against pests is briefly discussed. A section of 68 pages deals with various methods of control, spraying and dusting equipment, and the application of dusts from aeroplanes.

1935 - Bilsing, S. W. Creating an entomological atmosphere in the South. J. Econ. Ent. 28(5):739-745.

Emphasis is laid on the importance of preparing the public mind by disseminating information concerning the potential dangers of insect pests in order to obtain support when a campaign has to be initiated; and in order to stimulate enthusiasm, the accomplishments of a few pioneers in entomological work in the southern United States are reviewed. The manner in which the respective menaces of the boll weevil (Anthonomus grandis Boh.), the pink boll worm (Platyedra gossypiella Saund.) and the Mediterranean fruit-fly (Ceratitis capitata Wied.) were dealt with there, is quoted to show what might have been accomplished had the public mind been sufficiently prepared for the advice offered in the case of A. grandis, and what has been accomplished in the case of the other 2 pests.

Bondy, F. F., and C. F. Rainwater. Entomology and zoology. S. C. Agr. Expt. Sta. Rpt. 48(1934-1935):43-55.

Injury by insect pests was, in general, somewhat below the average in South Carolina in 1935, but an increase in damage to cotton by Anthonomus grandis Boh. was observed.

1935 - Hixon, E. The more important insect pests during 1932-1934. Okla. Agr. Expt. Sta. Rpt. p. 256-259.

Among pests of cotton in Oklahoma, Anthonomus grandis Boh. was kept in check by dry weather, Heliothis obsoleta F. was more prevalent on cotton, and Aphis gossypii Glov. caused serious injury when the crop was grown near cowpeas or okra (Hibiscus esculentus).

1942 - Webb, J. L. Cotton or boll weevils. U. S. D. A. Misc. Pub. 484, 16 p. Supercedes Misc. Pub. 35.

A popular account of the boll weevil which includes its description and development, hibernation, injury to the crop, origin and spread, natural control, and means of controlling the pest.

1945 - Cavendish, R. A. E. Plantation pest. Fauna 7(2):48-49.

Contains photographs of the developing boll weevil adult within the boll.

1949 - Davis, W. O. How Halifax growers get $5,000,000 more for cotton. Prog. Farmer 4:130. Apr.

In 1925, 70,000 acres of cotton were planted in Halifax County (Texas) which made 58,000 bales and $5,500,000 income. By 1939 cotton acreage had dropped to 30,000, production to 9,600 bales, and income to $500,000. This loss was due directly to boll weevil damage.

Something had to be done. In 1940 the "Halifax County Production and Boll Weevil Control Program" was established. A group of cotton farmers met at the county agent's office to discuss the problem. The group selected a county cotton committee composed of 5 farmers, 1 cotton ginner, 1 farm banker, 1 fertilizer dealer, and 1 farm merchant. This committee, with the help of the county agent and a State College extension cotton specialist, and a State College extension entomologist drew up a long-term "Halifax County Cotton Program."

1960 - Knipling, E. F. Use of insects for their own destruction. J. Econ. Ent. 53(3):415-420.

Theoretical calculations to show that a low-level mortality which is constant and superimposed on mortality produced by normal environmental resistance can in time lead to a greatly reduced population. The importance of applying control measures against the total population, rather than against segments of the population is pointed out.

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